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CORPS OF ENGINEERS, U. S. ARMY

FLOOD-CONTROL STILLING BASIN, BUFORD DAM
CHATTAHOOCHEE RIVER, GEORGIA

HYDRAULIC MODEL INVESTIGATION



TECHNICAL MEMORANDUM NO. 2-350

WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

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OCTOBER 1952

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PREFACE

Model investigations of the flood-control stilling basin for Buford Dam, Chattahoochee River, Georgia, were authorized by the Chief of Engineers in the tenth indorsement, dated 14 November 1951, to a letter dated 3 November 1950, from the Mobile District through the South Atlantic Division to the Office, Chief of Engineers. The model study was conducted in the Hydraulics Division of the Waterways Experiment Station during the period December 1951 to March 1952. Personnel actively connected with the model study were Messrs. F. R. Brown, T. J. Buntin, J. H. Ables, Jr., and N. V. Cowan.

Messrs. L. G. Leach and E. L. Belladonna of the South Atlantic Division and G. W. Gaines, C. E. Bentzel and E. A. Jones of the Mobile District visited the Waterways Experiment Station during the course of the study to observe model operation and discuss test results.

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SUMMARY

Model investigations of the flood-control stilling basin for Buford Dam were conducted on a 1:25-scale model to verify the hydraulic design of the basin and to determine if flow conditions could be improved by the addition of baffle piers or by revisions to the end sill. The removal of the right training wall also was investigated to determine whether such revision would impair flow conditions. The length, width, and elevation of the stilling basin were fixed by other considerations and could not be altered.

Tests indicated that, although flow conditions in the original design basin were generally satisfactory, improved performance would result by increasing the end sill height from 5 to 7.5 ft. The addition of baffle piers to the apron was not considered necessary. The tests also indicated that the right training wall length should be maintained as originally designed.

FLOOD-CONTROL STILLING BASIN, BUFORD DAM

CHATTAHOOCHEE RIVER, GEORGIA

Hydraulic Model Investigation

PART I: INTRODUCTION

Pertinent Features of the Project

1. Buford Dam is a rolled-earth-fill dam under construction on the Chattahoochee River approximately 35 miles northeast of Atlanta, Georgia (fig. 1). The main dam will be approximately 200 ft high and 1600 ft long. A series of saddle dikes in the surrounding hills will complete the system and provide a reservoir of 418,000 acres at spillway crest elevation of 1085* and a total storage capacity of 2,495,000 acre-ft.



Fig. 1. Vicinity map

2. A powerhouse and flood-control structure will be located in the right abutment of the dam. The powerhouse will have two large units of 55,000 horsepower each and one small unit of 8,400 horsepower. Water will be conveyed to the powerhouse through tunnels which will be used for diversion flow during construction of the main dam. The two large units will be served by 22-ft-diameter penstocks. The small unit will be served by a 10-ft-diameter

* All elevations are in feet above mean sea level.

penstock branching off from one of the large penstocks.

3. The flood-control structure will consist of an intake tower, a single tunnel 13.25 ft in diameter and about 350 ft in length, and a stilling basin. The flood-control structure is designed to pass a discharge of 11,750 cfs at the maximum reservoir elevation of 1100. Normal flow regulation will be accomplished by means of two broome-type gates 6.5 ft wide by 13.25 ft high located in the intake tower. The flood-control stilling basin will be of the hydraulic-jump type with an overall length of 225 ft and a maximum width of 41 ft. The drop from tunnel invert to stilling basin apron will be 21.75 ft (plate 1). During the course of the model tests baffle piers were found unnecessary and the end sill was increased in height from 5 ft to 7.5 ft.

4. Flows exceeding the storage capacity of the reservoir will pass over an uncontrolled chute-type spillway located in a saddle about one mile east of the main dam. The spillway is designed to pass a maximum discharge of 16,300 cfs under a head of 15.0 ft. The crest of the spillway is at elevation 1085. Flow will pass through the spillway and into the natural drainage channel with no reduction in velocities.

Purpose of Model Analysis

5. Sufficient data from previous model studies of intake structures and conduit flow were available to insure adequate design criteria for the flood-control intake and sluice. However, studies of the flood-control stilling basin were considered necessary inasmuch as velocities as high as 90 ft per sec are expected at the outlet portal. The studies reported herein were confined to determination of the adequacy of the

original design stilling basin and the possibility of improvements there-
to by modification of the end sill or addition of baffle piers. The pos-
sibility of a reduction in length or elimination of the right training
wall also was to be determined. The Mobile District Office instructed
that no changes were to be made to the length, width, and elevation of
the stilling basin.

PART II: THE MODEL

Description

6. The model of Buford Dam flood-control stilling basin was constructed to an undistorted scale ratio of 1:25 and reproduced approximately 104 ft of the downstream end of the sluice, the entire flood-control stilling basin, and about 300 ft of the exit area downstream from the powerhouse and flood-control stilling basin (see fig. 2 and plate 2). The sluice was constructed of sheet metal. The stilling basin, side walls, and basin elements were fabricated of wood. Those portions of the model representing the exit channel and overbank areas were molded in cement

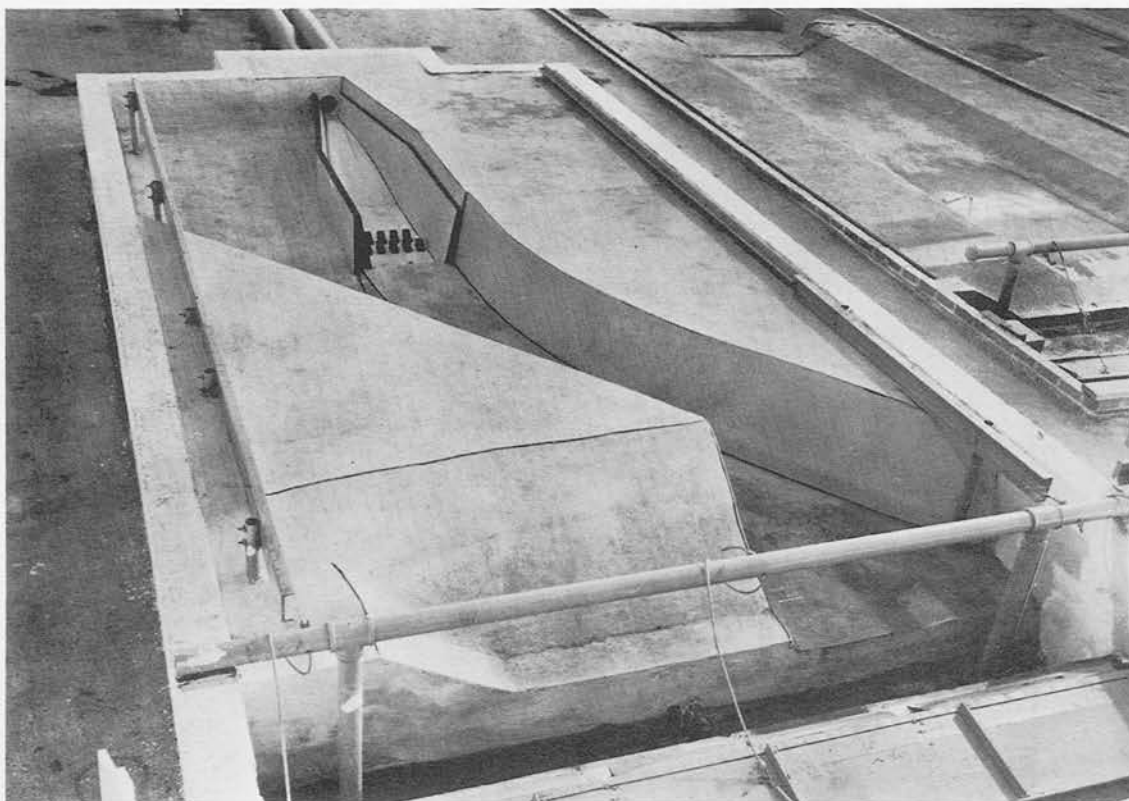


Fig. 2. Buford Dam flood-control stilling basin model

mortar to sheet-metal templets. Steel rails set to grade along each side of the model provided a reference plane for all measuring devices. Water-surface elevations were measured by means of a portable sounding rod placed on an angle beam supported by the rails. Velocities were measured by means of a pitot tube so constructed as to permit measurements for any direction of flow. Flow conditions were recorded photographically. Pressures were measured by means of piezometers installed in the model and connected to a gage by copper tubing.

7. The water used in the operation of the model was supplied by a circulating system, the measurement of discharge being accomplished by use of a venturi meter installed in the inflow line. Flow from the supply line was discharged into the headbay where it was stilled by baffles prior to its entrance into the model sluice. The tailwater elevation in the exit area was controlled by an adjustable tailgate. After passing over the tailgate the water flowed through a return line back to the sump from which it was originally pumped.

Scale Relationships

8. The accepted equations of hydraulic similitude, based upon the Froudian relationships, were used to express the mathematical relationships between the dimensions and the hydraulic quantities of the model and the prototype. General relationships for transference of model data to prototype equivalents, or vice versa, are presented in the following table:

<u>Dimension</u>	<u>Ratio</u>	<u>Scale Relationship</u>
Length	L_r	1:25
Area	$A_r = L_r^2$	1:625
Velocity	$V_r = L_r^{1/2}$	1:5
Discharge	$Q_r = L_r^{5/2}$	1:3125

PART III: TESTS AND RESULTS

9. Tests of the stilling basin were made for conditions of: (a) original design, (b) one row of 5-ft-high baffle piers located at sta 1+86, (c) two rows of 5-ft-high baffle piers located at sta 1+71 and 1+86, (d) end sill increased in height to 7.5 ft, and (e) right training wall reduced in length. Data were obtained for discharges of 11,750, 10,800, 10,430, and 3,800 cfs corresponding respectively to maximum pool elevation, maximum flood-control pool elevation, maximum power pool elevation, and full sluice flow. Normal tailwater elevations as computed for the flood-control sluice operating independently were used for downstream control. Some photographic data were obtained for discharges of 11,500 and 7,500 cfs, in addition to the discharges listed above, to indicate the effect of variation in tailwater above and below computed elevation.

Tests of Original Design

10. Details of the original design stilling basin, with the exception of the baffle piers, are shown on plate 1. Baffle piers were omitted from the original design basin. Water-surface profiles, current directions, velocities, and spray data are shown on plates 3-9. Flow conditions are shown on photographs 1-12.

11. Flow conditions in the stilling basin were generally satisfactory throughout the entire range of discharge. A satisfactory hydraulic jump formed in the stilling basin, although a portion of the jump extended into the exit channel during high flows. Downstream from the end sill considerable wave action resulted from impingement of the flow on the

right bank. Eddy action and some upstream currents existed downstream from the right training wall. An increase of 5 ft in tailwater elevation had no appreciable effect on jump action within the basin unless the right training wall was overtopped (photographs 4-5). The tailwater could be lowered about 6 ft before spray action existed for discharges in the range of 10,000 to 11,000 cfs (plate 9). The tailwater could be lowered still further for discharges above 11,250 cfs and below 10,000 cfs before spray existed.

12. Bottom velocities in the exit channel were negligible for all discharges. A maximum downstream velocity of 16 ft per sec was recorded over the end sill for a discharge of 11,750 cfs (plate 5); bottom velocities over the end sill for discharges of 10,800 and 10,430 cfs (plates 6 and 7) were upstream in direction and varied from 10 to 17 ft per sec. For a discharge of 10,430 cfs, flow appeared to be concentrated in the left side of the stilling basin.

Alterations to Original Design

One row of baffle piers

13. One row of 5-ft-high baffle piers (plate 1) was added to the basin of original design at sta 1+86. The baffle piers appeared to stabilize the position of the hydraulic jump and deflected bottom currents away from the end sill. Data presented on plate 10 indicate that velocities immediately over the end sill were negligible.

Two rows of baffle piers

14. An additional row of 5-ft-high baffle piers was added at sta 1+71 (plate 1) and complete flow data obtained (see photographs

13-16 and plates 11-16).

15. Flow conditions with two rows of baffle piers were satisfactory for all conditions of discharge. Good hydraulic jump action existed and the distribution of flow across the end sill appeared to be slightly better than that observed with no baffle piers. Bottom velocities over the end sill and in the exit area were negligible. The basin, however, was slightly more susceptible to spray action with the baffle piers installed (plate 9). For a discharge of 11,000 cfs the tailwater could be lowered only 4.5 ft below normal before spray occurred as compared to a reduction of 6 ft in tailwater possible before spray action occurred in the basin without baffle piers.

Increased end sill height

16. Engineers of the Mobile District did not desire to include baffle piers in the stilling basin design because of initial and possible maintenance costs. Since the test data indicated safe conditions without baffle piers, efforts were directed toward the further improvement of flow conditions by revisions to the end sill. A series of short observation tests indicated best performance could be obtained with the end sill height increased from 5 to 7 or 8 ft. Therefore, a 7.5-ft end sill was selected for detailed investigation (plate 17).

17. Flow conditions were generally improved by use of the higher end sill and compared favorably with those observed with two rows of baffle piers installed in the stilling basin (photographs 17-22). Comparative water-surface profiles and current direction plots are shown on plates 12 and 18, respectively. Bottom velocities were slightly higher over the end sill than with two rows of baffle piers installed,

being in the range of 4 to 8 ft per sec. Bottom velocities in the exit area were negligible (plate 19). Spray data are presented on plate 9.

18. Piezometers were installed on the top step of the end sill as indicated on plate 17 and pressures obtained for a complete range of discharges. The pressures obtained (table 1) were approximately the same as the depth of tailwater, thus indicating that no excessive overturning force would be exerted on the end sill.

Reduced length, right training wall

19. Consideration was given to the possibility of reducing in length or eliminating entirely the right training wall and tests were made with the wall shortened 108 ft to sta 1+17 (see fig. 3).

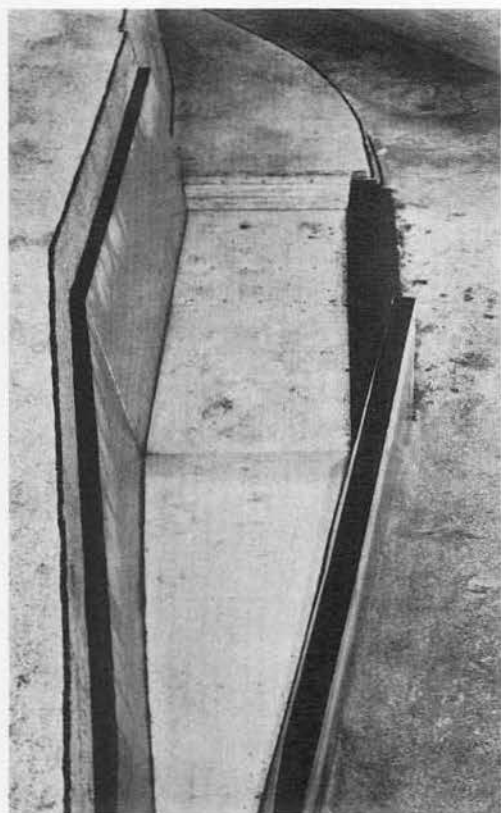


Fig. 3. Right training wall shortened 108 ft to sta 1+17.0

20. Photographs 23-28 indicate that flow conditions within the stilling basin and exit area with the shortened wall were considerably more turbulent than with the wall of original length. Eddy action in the area to the right of the training wall confined flow to the left side of the stilling basin. Large waves formed during high discharges and occasionally overtopped the bank of the right side of the exit channel. Flow conditions were so unsatisfactory that further reduction in the training wall length was not investigated.

PART IV: DISCUSSION

21. Model investigations of the flood-control stilling basin for Buford Dam provided information on the basin of original design and indicated the feasibility of minor revisions to improve flow conditions. Omission of baffle piers from the stilling basin was found permissible. The model results also indicated that increasing the height of the end sill as originally designed by 2.5 ft improved flow conditions. A more stable hydraulic jump existed in the basin with the height of end sill increased and a greater drop in tailwater elevation was possible before spray action resulted. Elimination or reduction in length of the right training wall is not recommended.

22. Flow conditions within the stilling basin of original design with a 7.5-ft-high end sill were satisfactory for all conditions of discharge. Bottom velocities over the end sill and in the exit channel were negligible. However, during high discharges surface velocities were as great as 20 ft per sec which could result in some erosion of overburden material along the adjacent left bank. Some erosion by wave attack also could occur on the right bank of the exit channel immediately downstream from the stilling basin.

Table 1

PRESSURE MEASUREMENTS ON THE 7.5-FT END SILL

Flow Conditions	Pressures					
	Piez No. 1		Piez No. 2		Piez No. 3	
	Max	Min	Max	Min	Max	Min
Discharge, 3,800 cfs Tailwater elev, 920.0	19.5	19.5	19.5	19.5	19.5	19.5
Discharge, 7,500 cfs Tailwater elev, 923.9	24.4	22.9	24.4	22.9	24.4	22.9
Discharge, 10,430 cfs Tailwater elev, 926.5	28.8	25.8	28.8	25.8	28.8	25.8
Discharge, 10,800 cfs Tailwater elev, 926.8	31.0	26.0	31.0	26.0	31.0	26.0
Discharge, 11,250 cfs Tailwater elev, 927.1	28.8	25.8	28.8	25.8	28.8	25.8
Discharge, 11,750 cfs Tailwater elev, 934.0	32.5	32.5	32.5	32.5	32.5	32.5

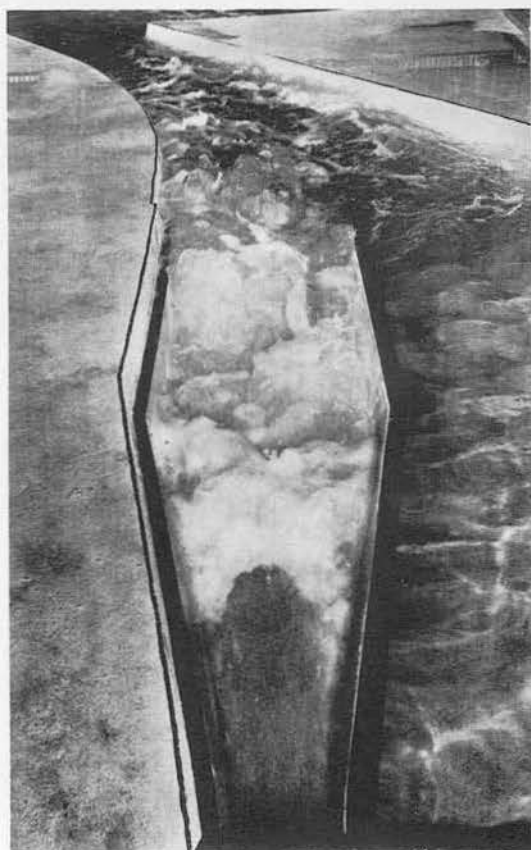
Notes: Pressures in feet of water were measured against the upstream face of the top step of the end sill at sta 2+22.5.

Piezometers 1, 2, and 3 are at elevation 899.0.

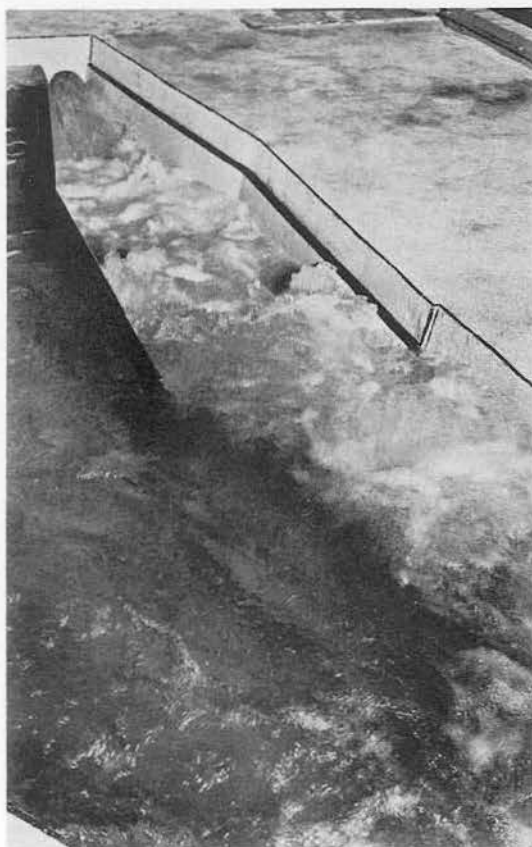
PHOTOGRAPHS



Photograph 1. Flow through
original design stilling basin
Discharge, 11,750 cfs
Tailwater elev, 922.0 (spray action)



Photograph 2. Downstream view
of flow through original
design stilling basin
Discharge, 11,750 cfs
Tailwater elev, 934.0 (normal)

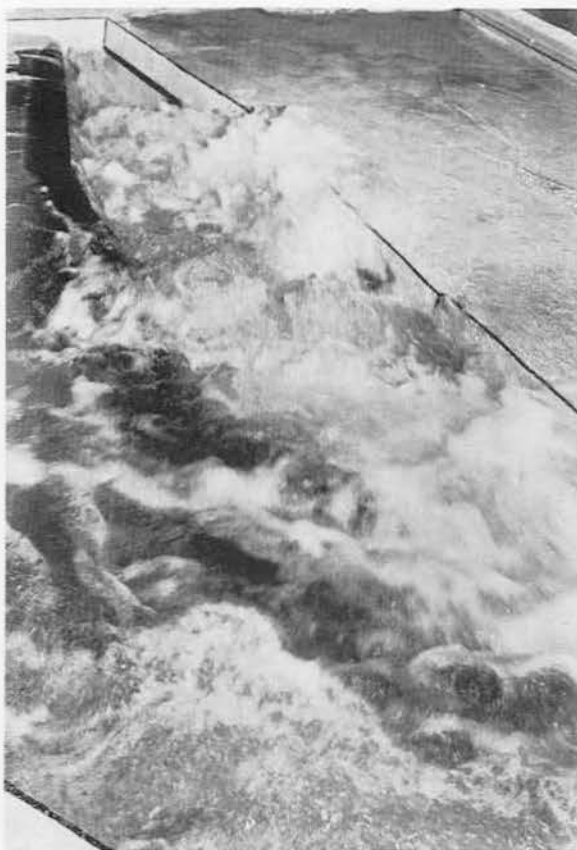


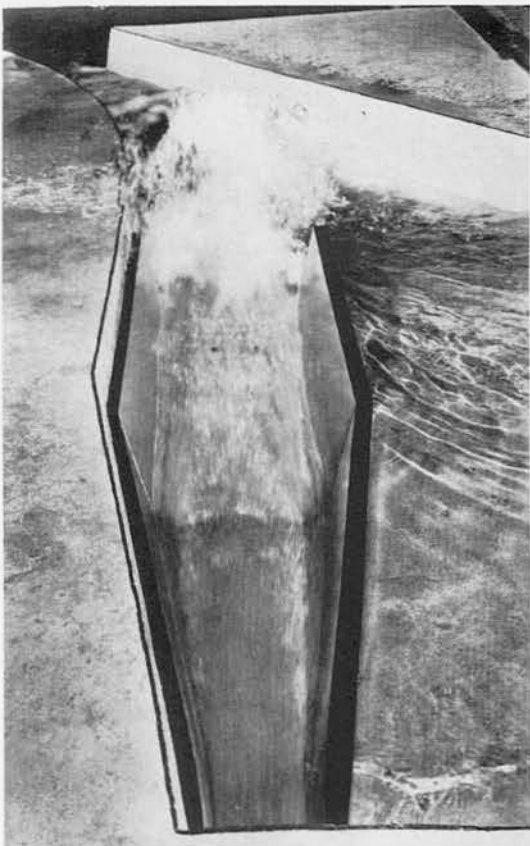
Photograph 3. Upstream view of
flow through original design
stilling basin
Discharge, 11,750 cfs
Tailwater elev, 934.0 (normal)



Photograph 4. Downstream view
of flow through original
design stilling basin
Discharge, 11,750 cfs
Tailwater elev, 939.0 (normal
+5.0 ft)

Photograph 5. Upstream view of
flow through original design
stilling basin
Discharge, 11,750 cfs
Tailwater elev, 939.0 (normal
+5.0 ft)





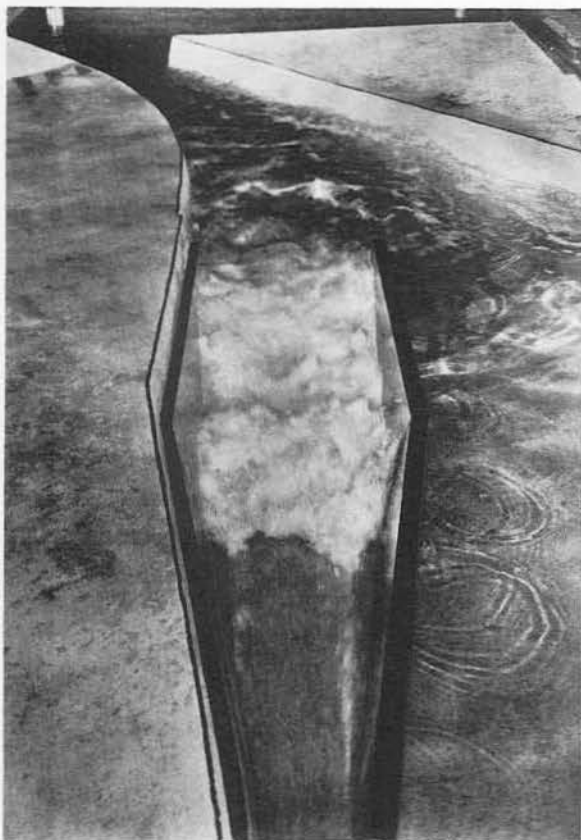
Photograph 6. Flow through
original design stilling basin
Discharge, 10,800 cfs
Tailwater elev, 920.5 (spray action)



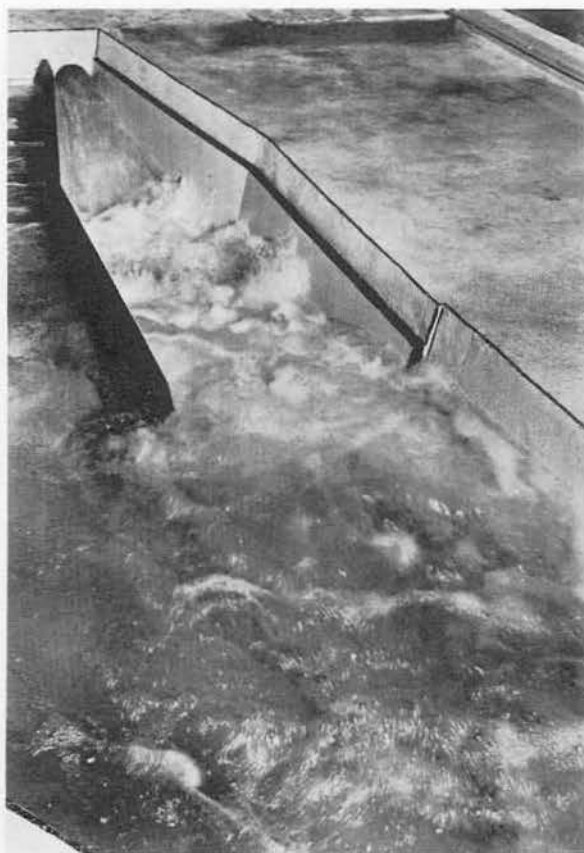
Photograph 7. Flow through
original design stilling basin
Discharge, 10,800 cfs
Tailwater elev, 926.8 (normal)



Photograph 8. Flow through
original design stilling basin
Discharge, 10,800 cfs
Tailwater elev, 931.8 (normal
+5.0 ft)

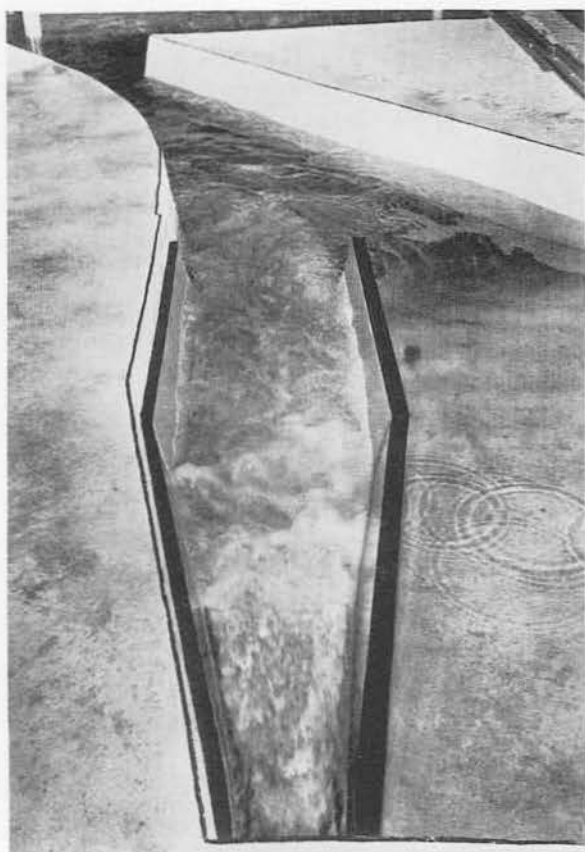


Photograph 9. Downstream view
of flow through original
design stilling basin
Discharge, 10,430 cfs
Tailwater elev, 926.5 (normal)

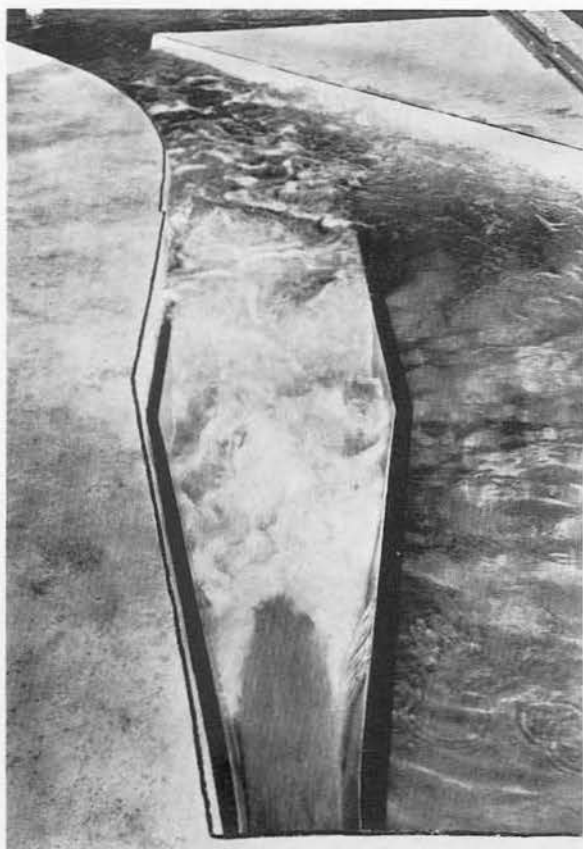


Photograph 10. Upstream view of
flow through original design
stilling basin
Discharge, 10,430 cfs
Tailwater elev, 926.5 (normal)

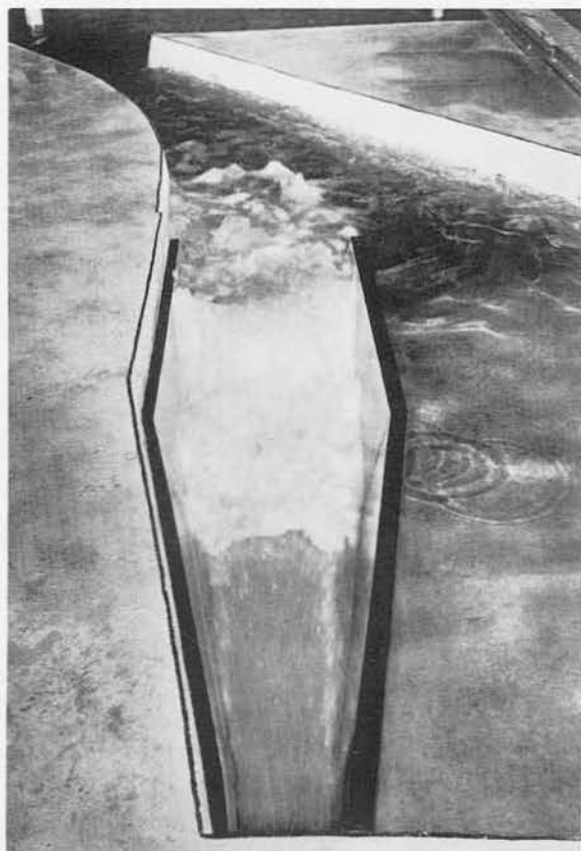
Photograph 11. Flow through
original design stilling basin
Discharge, 7,500 cfs
Tailwater elev, 923.9 (normal)



Photograph 12. Flow through
original design stilling basin
Discharge, 3,800 cfs
Tailwater elev, 920.0 (normal)

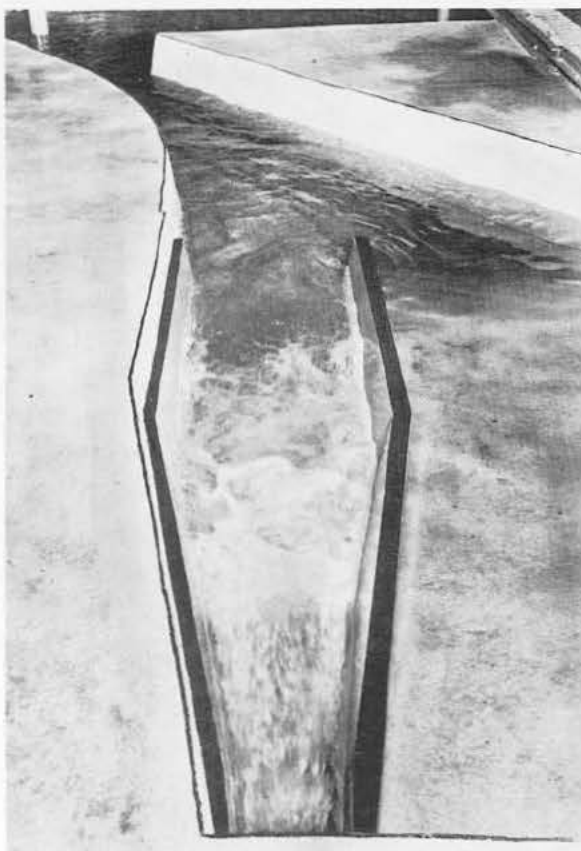


Photograph 13. Flow through
 original design stilling basin
 with 2 rows of baffle piers
 Discharge, 11,750 cfs
 Tailwater elev, 934.0 (normal)



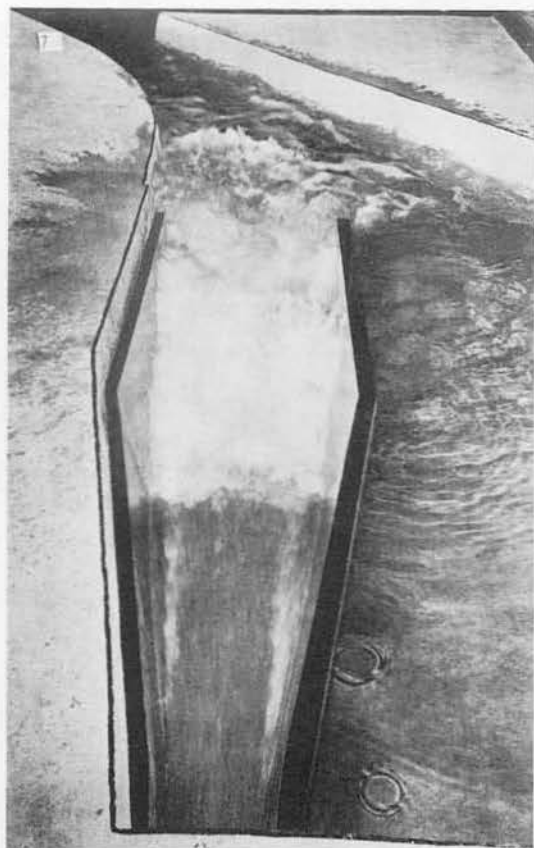
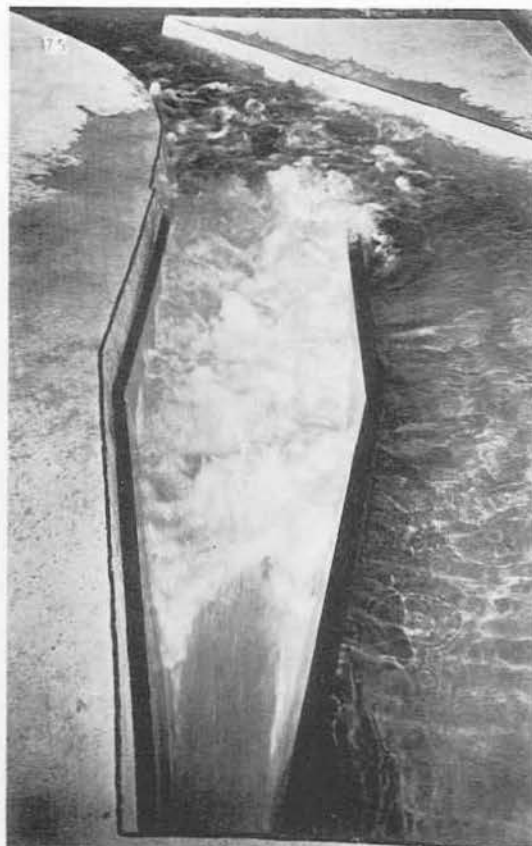
Photograph 14. Flow through
 original design stilling basin
 with 2 rows of baffle piers
 Discharge, 10,800 cfs
 Tailwater elev, 926.8 (normal)

Photograph 15. Flow through
original design stilling basin
with 2 rows of baffle piers
Discharge, 7,500 cfs
Tailwater elev, 923.9 (normal)



Photograph 16. Flow through
original design stilling basin
with 2 rows of baffle piers
Discharge, 3,800 cfs
Tailwater elev, 920.0 (normal)

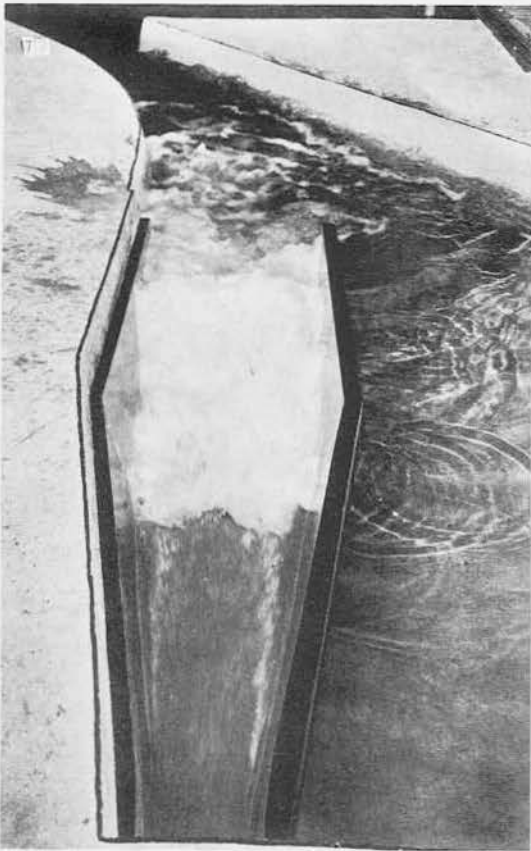
Photograph 17. Flow through
 original design stilling basin
 with 7.5-ft end sill
 Discharge, 11,750 cfs
 Tailwater elev, 934.0 (normal)



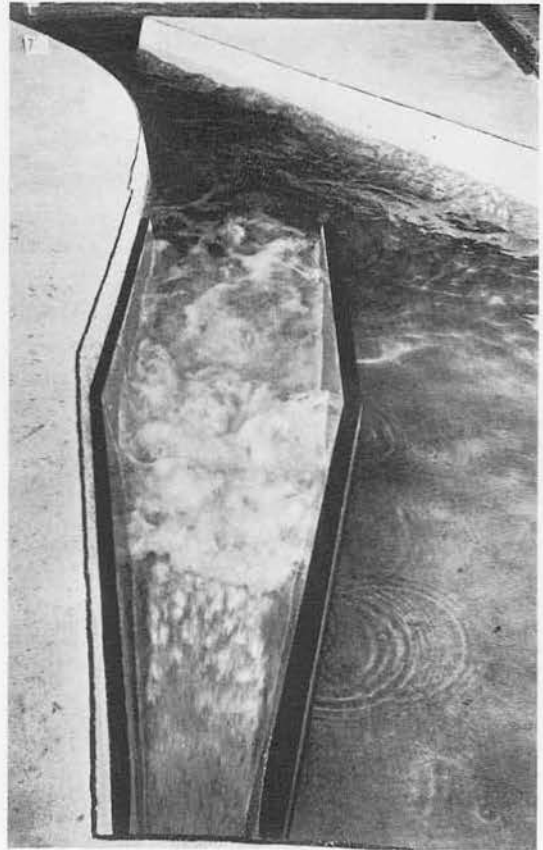
Photograph 18. Flow through
 original design stilling basin
 with 7.5-ft end sill
 Discharge, 11,250 cfs
 Tailwater elev, 927.1 (normal)



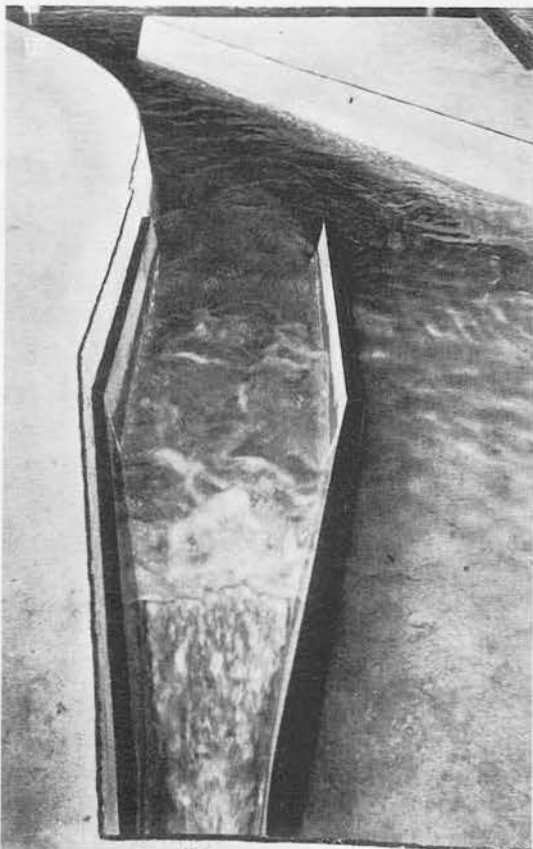
Photograph 19. Flow through
 original design stilling basin
 with 7.5-ft end sill
 Discharge, 10,800 cfs
 Tailwater elev, 926.8 (normal)



Photograph 20. Flow through
original design stilling basin
with 7.5-ft end sill
Discharge, 10,430 cfs
Tailwater elev, 926.5 (normal)

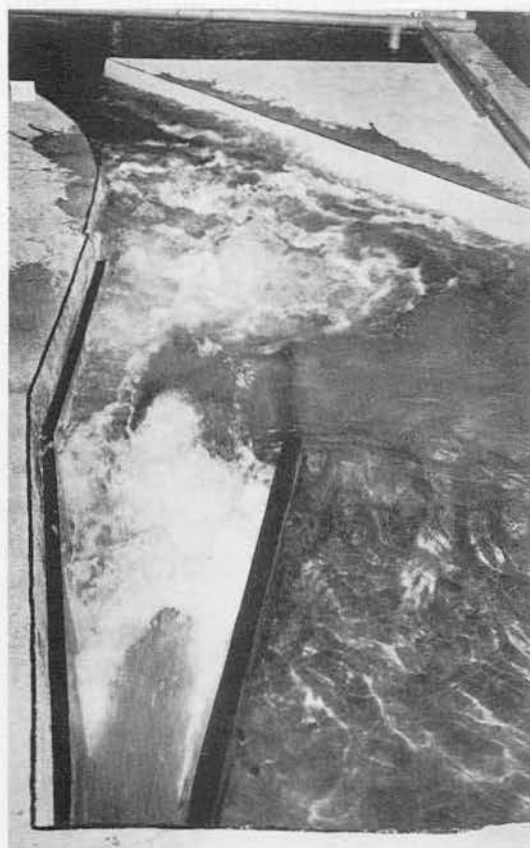
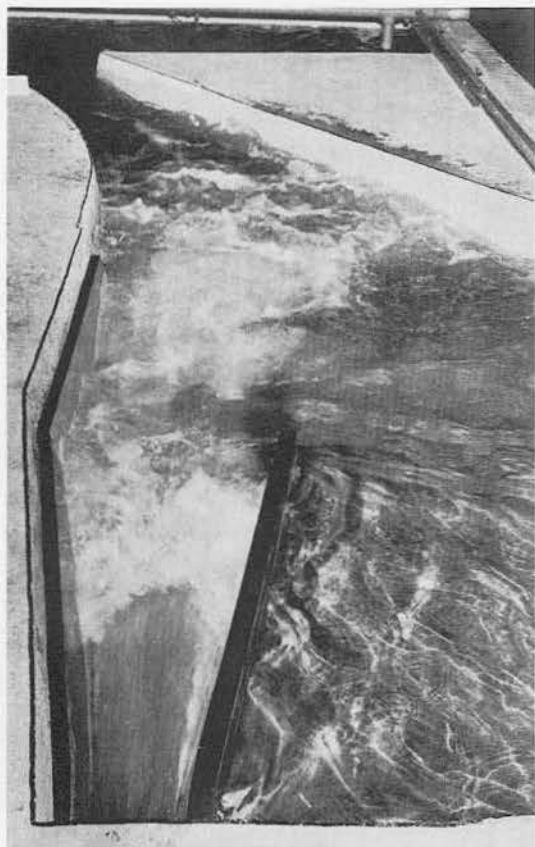


Photograph 21. Flow through
original design stilling basin
with 7.5-ft end sill
Discharge, 7,500 cfs
Tailwater elev, 923.9 (normal)



Photograph 22. Flow through
original design stilling basin
with 7.5-ft end sill
Discharge, 3,800 cfs
Tailwater elev, 920.0 (normal)

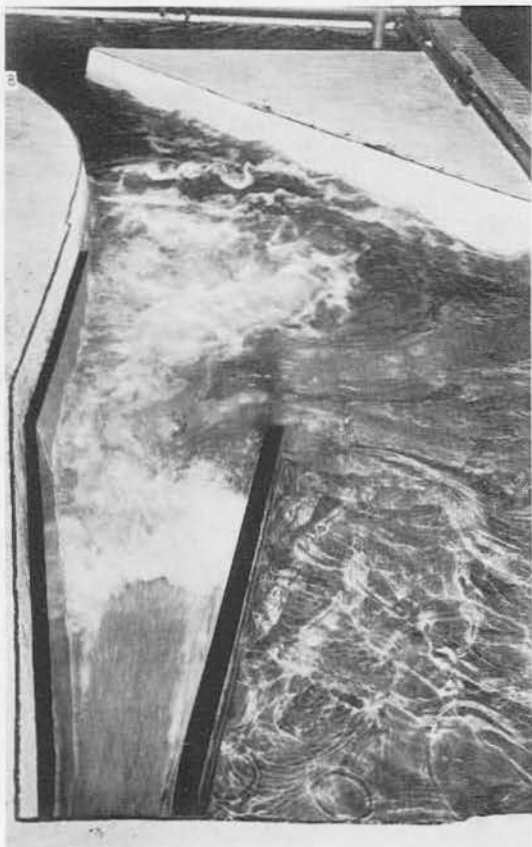
Photograph 23. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 11,750 cfs
Tailwater elev, 934.0 (normal)



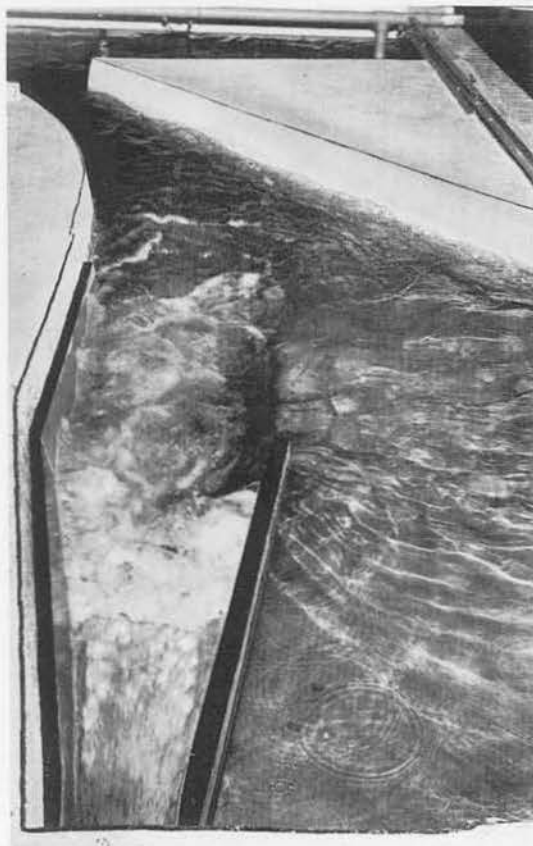
Photograph 24. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 11,250 cfs
Tailwater elev, 927.1 (normal)



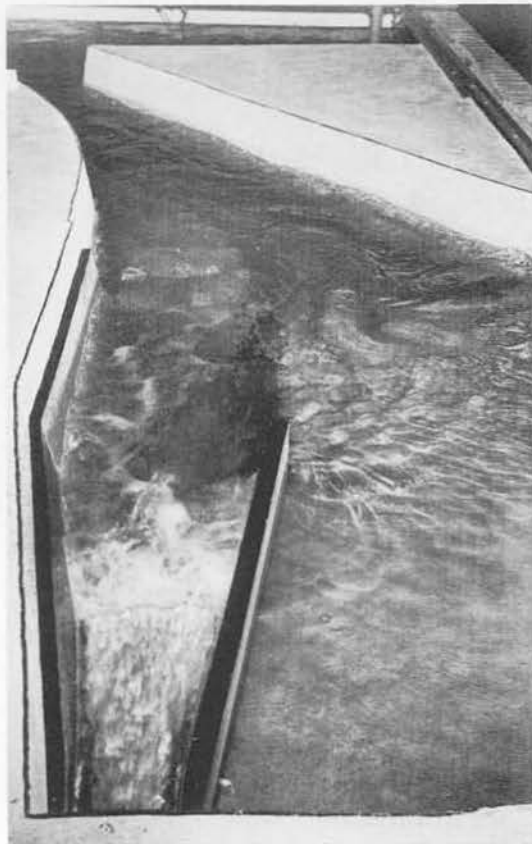
Photograph 25. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 10,800 cfs
Tailwater elev, 926.8 (normal)



Photograph 26. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 10,430 cfs
Tailwater elev, 926.5 (normal)

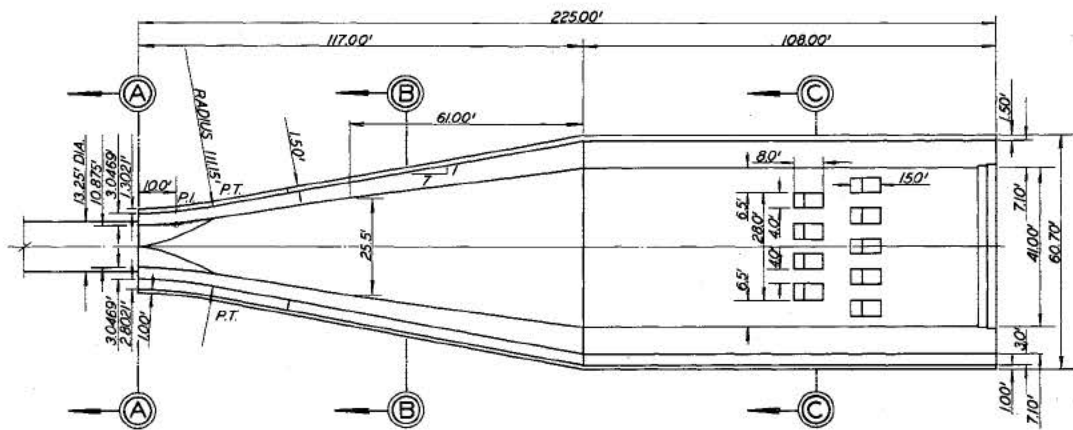


Photograph 27. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 7,500 cfs
Tailwater elev, 923.9 (normal)

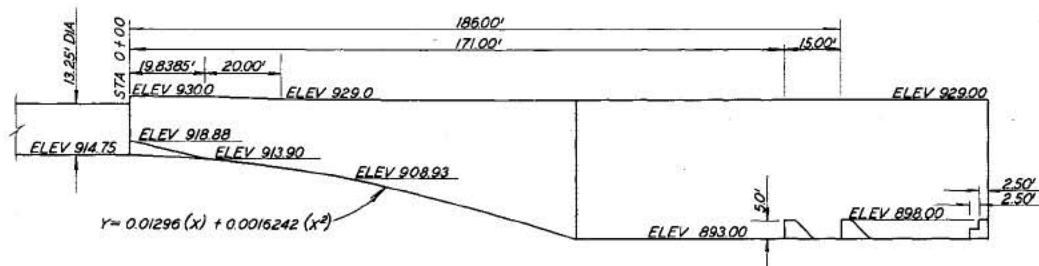


Photograph 28. Flow through
original design stilling basin
with 7.5-ft end sill,
right wall shortened 108 ft
Discharge, 3,800 cfs
Tailwater elev, 920.0 (normal)

PLATES

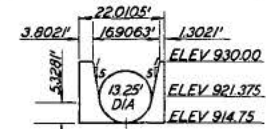
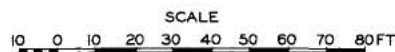


PLAN

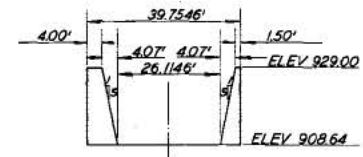


ELEVATION

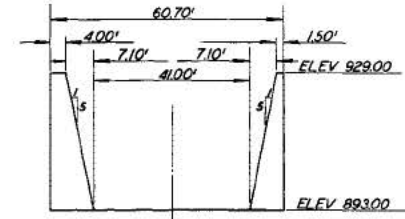
NOTE: ELEVATIONS ARE IN FEET MSL.



SECTION A-A

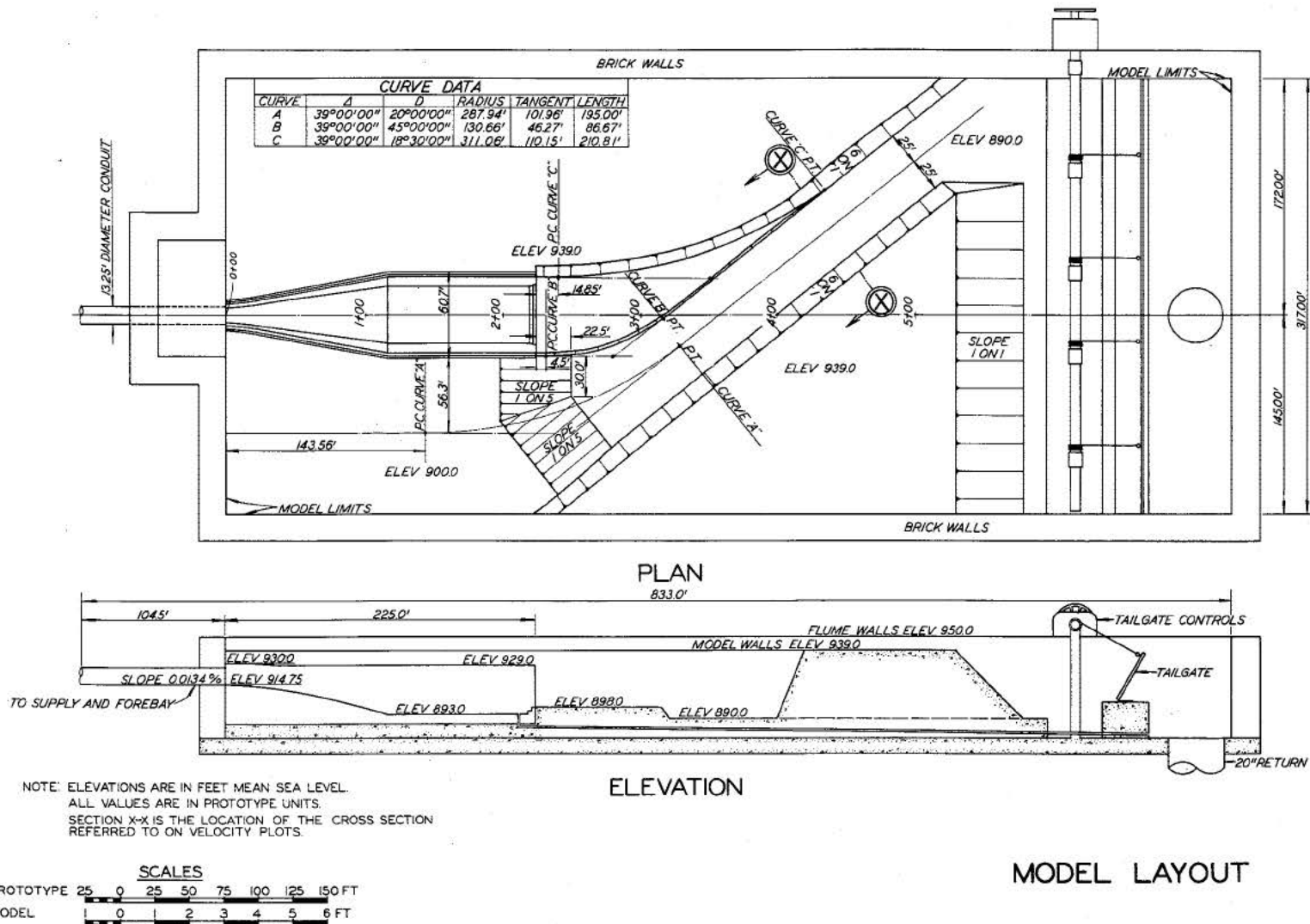


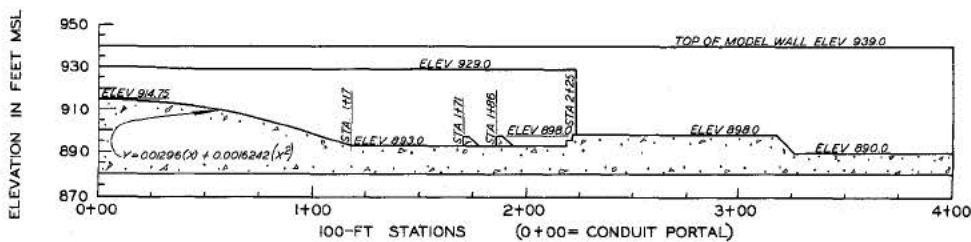
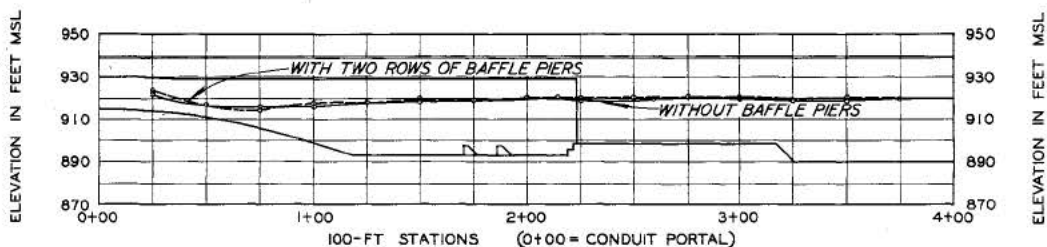
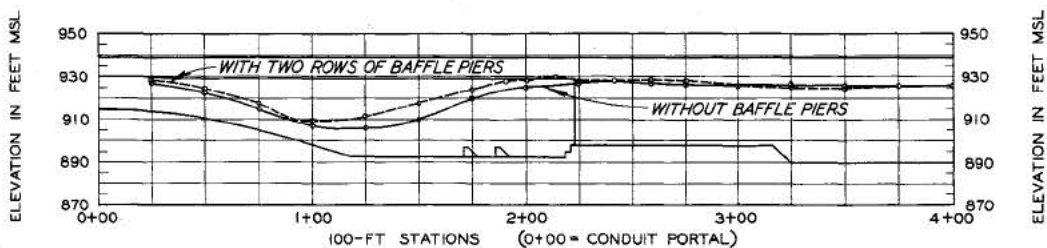
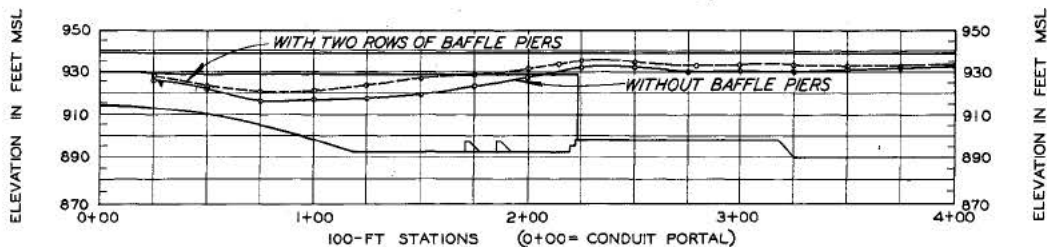
SECTION B-B



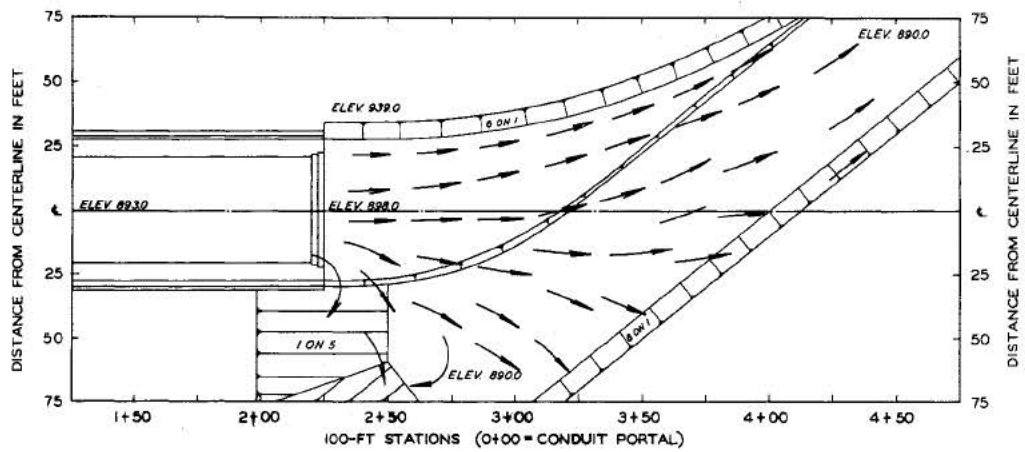
SECTION C-C

DETAILS OF STILLING BASIN

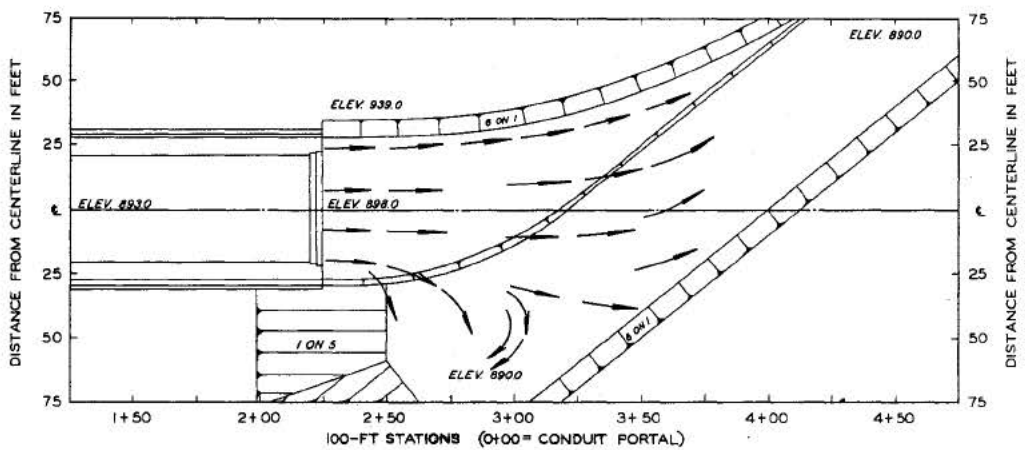




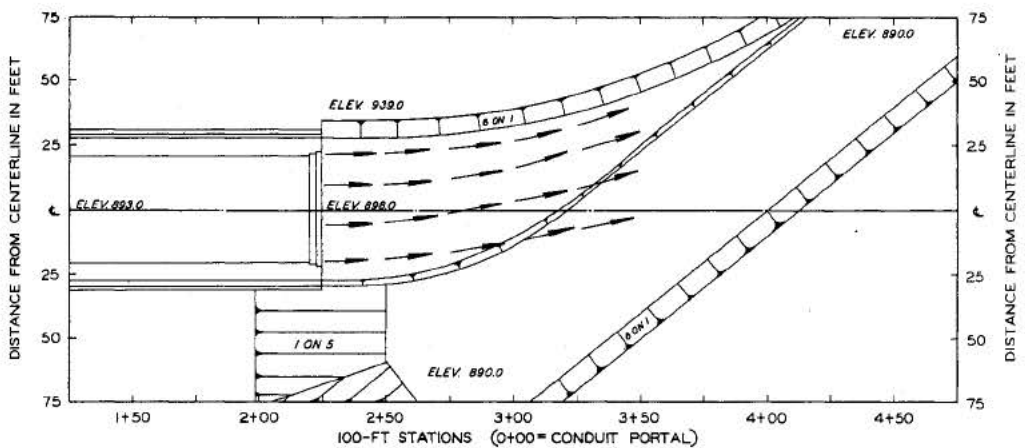
WATER-SURFACE PROFILES



DISCHARGE 11,750 CFS TAILWATER ELEVATION 934.0



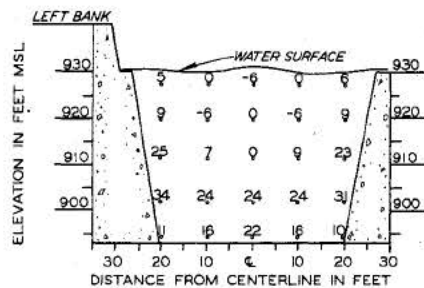
DISCHARGE 10,430 CFS TAILWATER ELEVATION 926.5



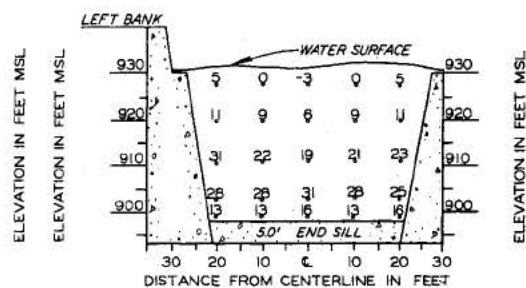
DISCHARGE 3,800 CFS TAILWATER ELEVATION 920.0

NOTE: ELEVATIONS ARE IN FEET MSL.

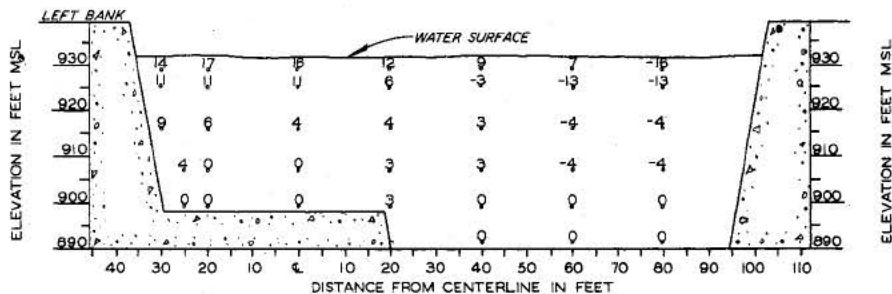
CURRENT DIRECTIONS
WITHOUT BAFFLE PIERS



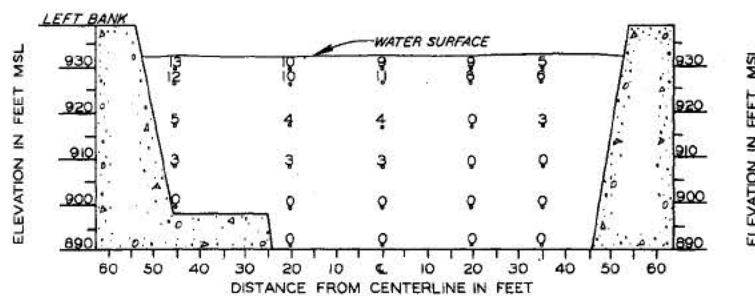
STATION 2+15



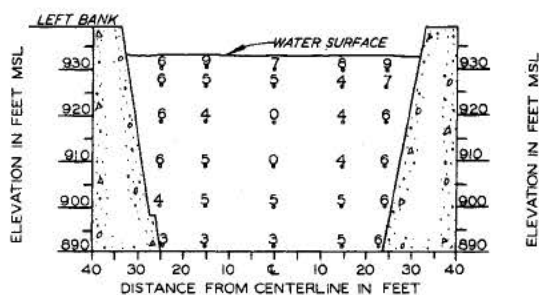
STATION 2+25



STATION 2+80



STATION 3+50



SECTION X-X

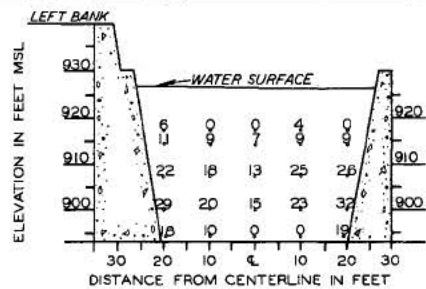
NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.

VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.

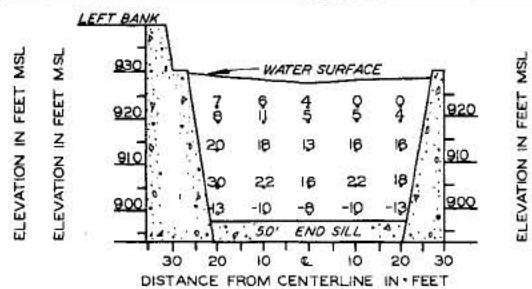
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

VELOCITIES WITHOUT BAFFLE PIERS

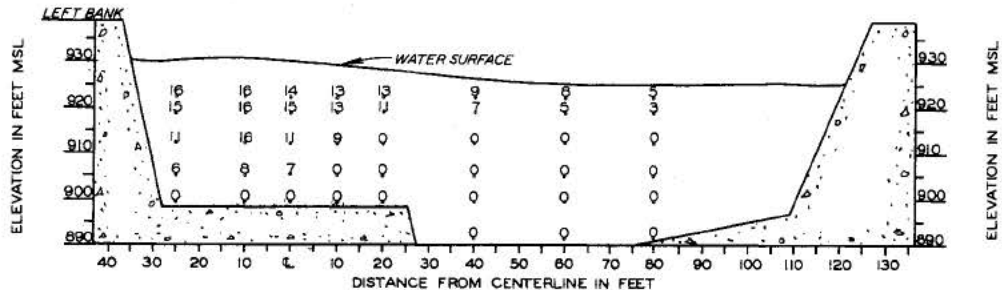
DISCHARGE 11,750 CFS
TAILWATER ELEVATION 934.0



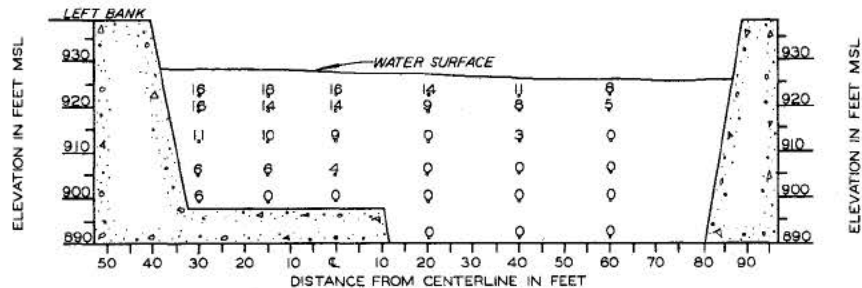
STATION 2+15



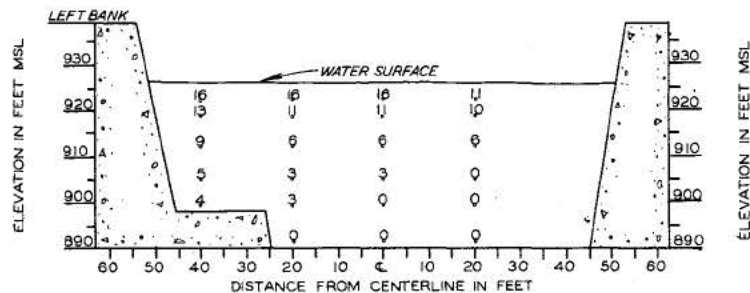
STATION 2+25



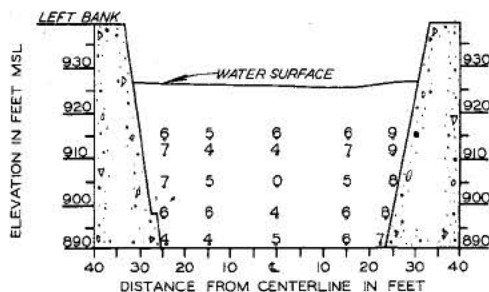
STATION 2+60



STATION 3+00



STATION 3+50

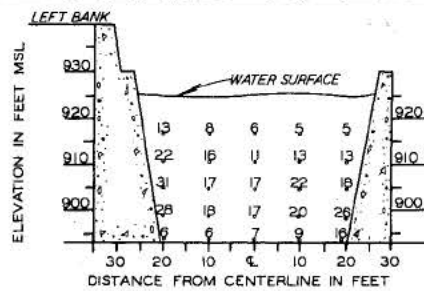


SECTION X-X

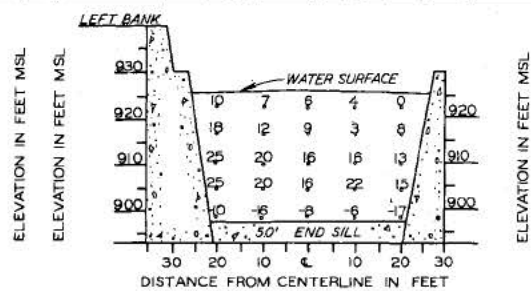
NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.
VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

VELOCITIES WITHOUT BAFFLE PIERS

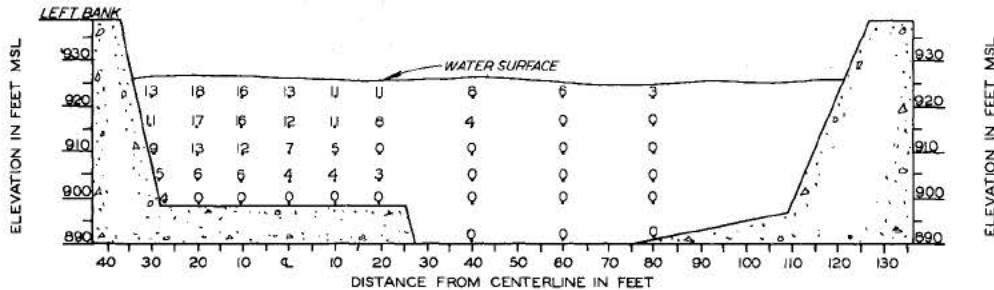
DISCHARGE 10,800 CFS
TAILWATER ELEVATION 926.8



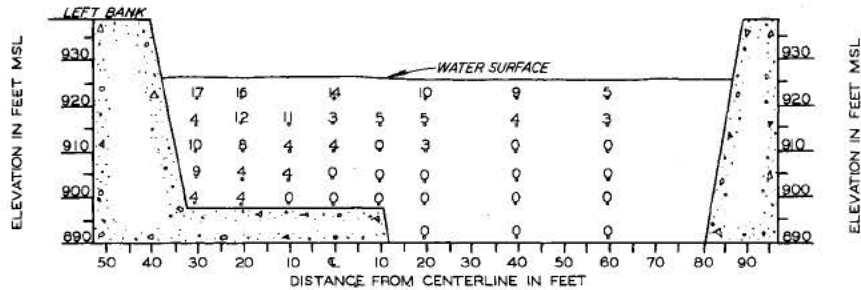
STATION 2+15



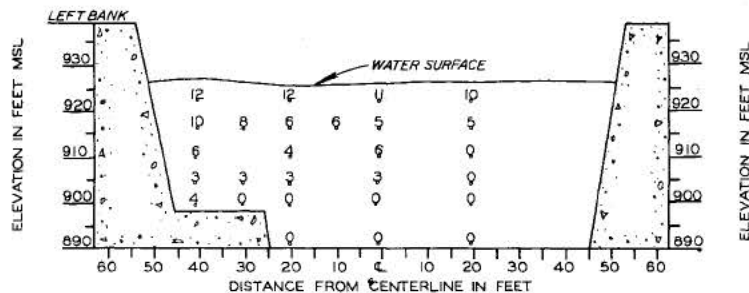
STATION 2+25



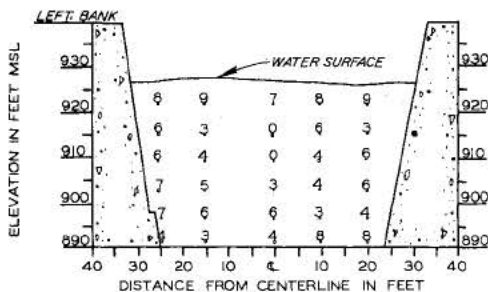
STATION 2+60



STATION 3+00



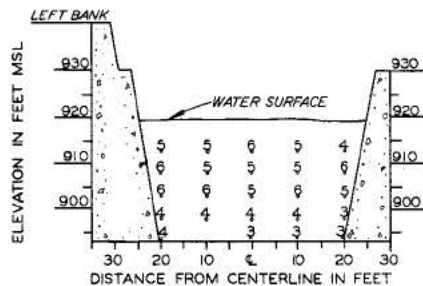
STATION 3+50



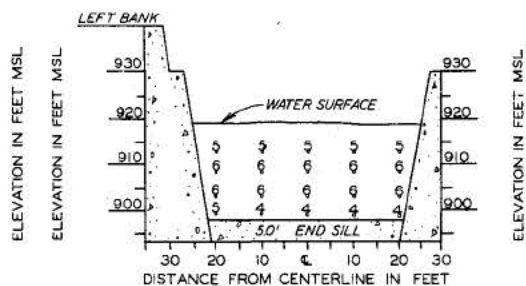
SECTION X-X

NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.
VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

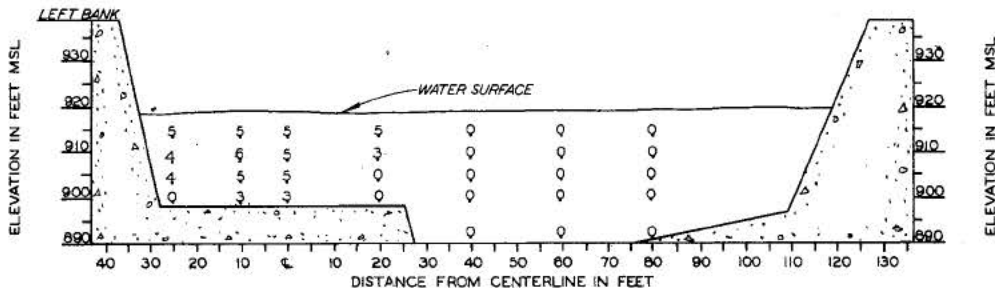
VELOCITIES
WITHOUT BAFFLE PIERS
DISCHARGE 10,430 CFS
TAILWATER ELEVATION 926.5



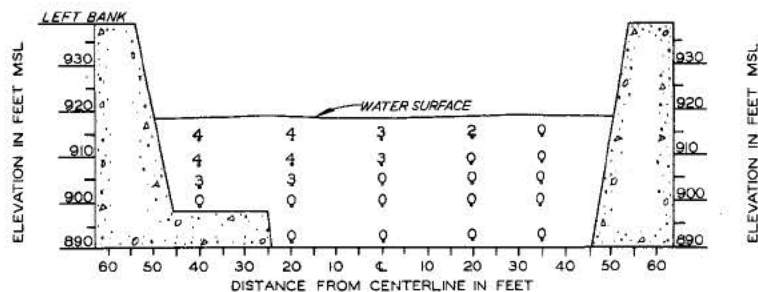
STATION 2+15



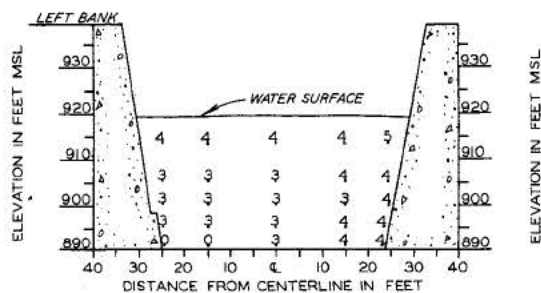
STATION 2+25



STATION 2+60



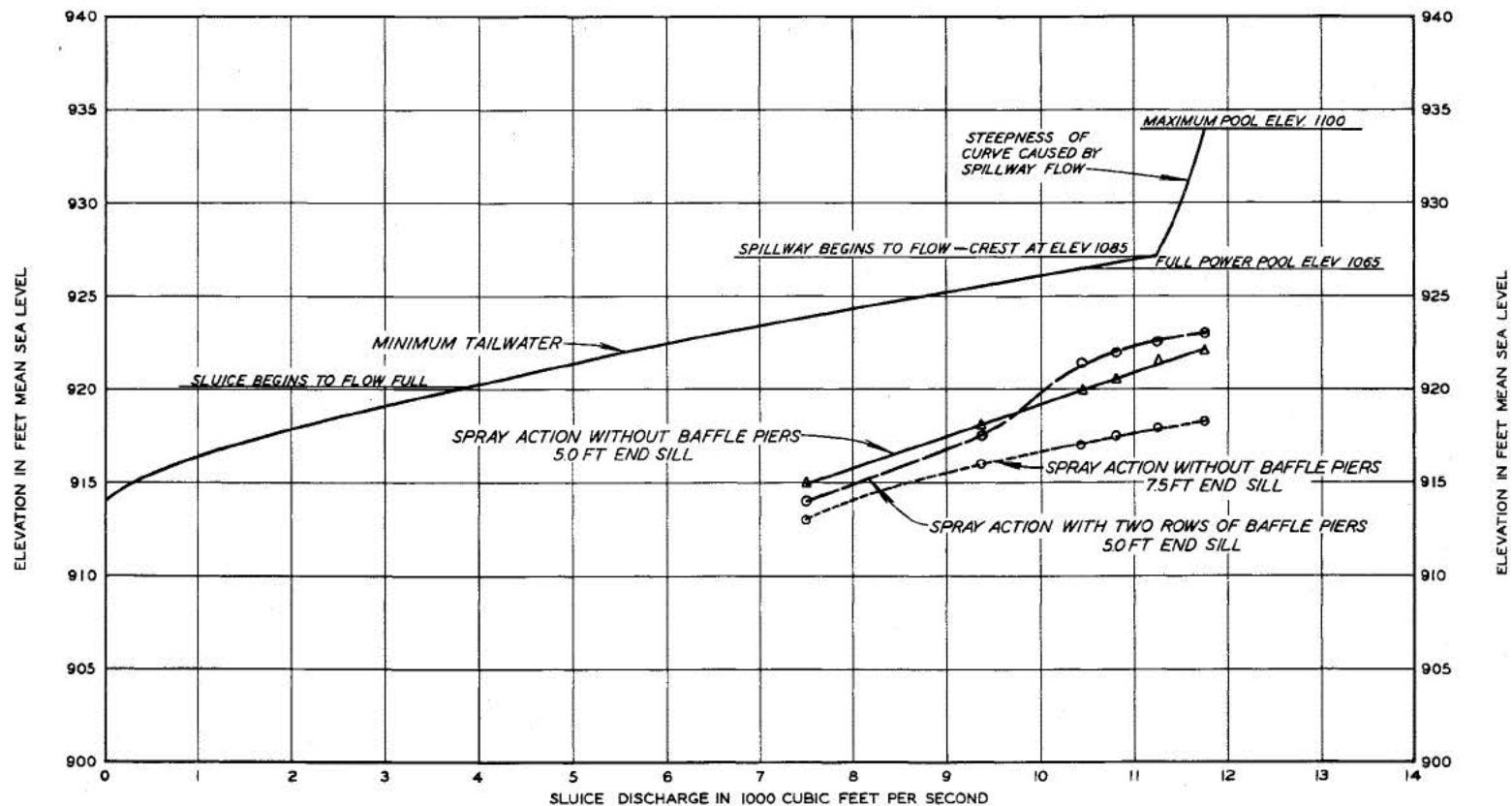
STATION 3+50



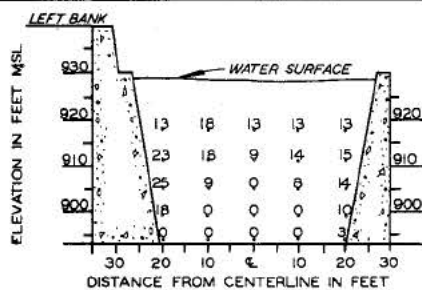
SECTION X-X

NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.
VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

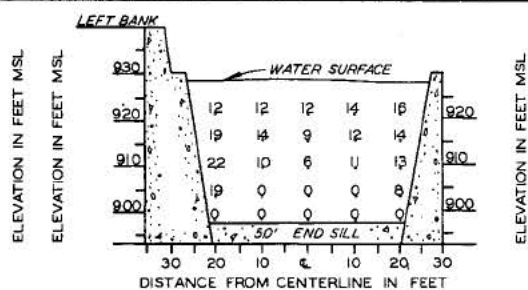
VELOCITIES
WITHOUT BAFFLE PIERS
DISCHARGE 3,800 CFS
TAILWATER ELEVATION 920.0



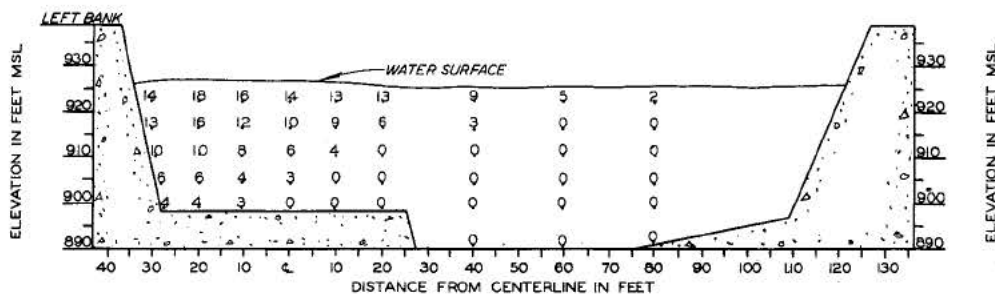
TAILWATER CHARACTERISTICS



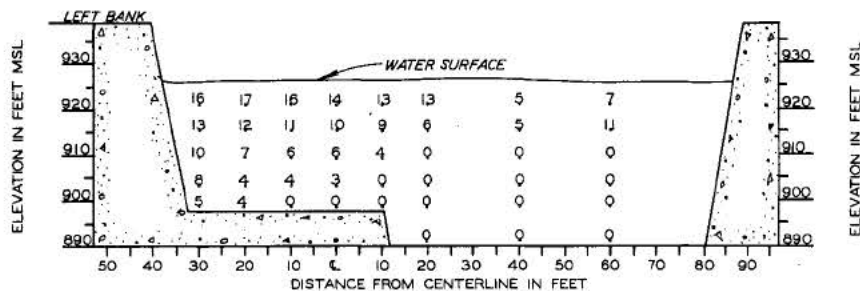
STATION 2+15



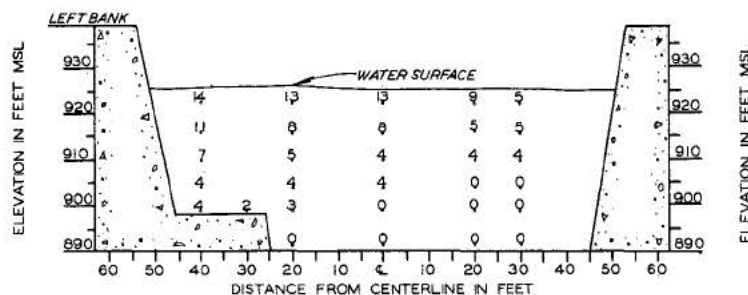
STATION 2+25



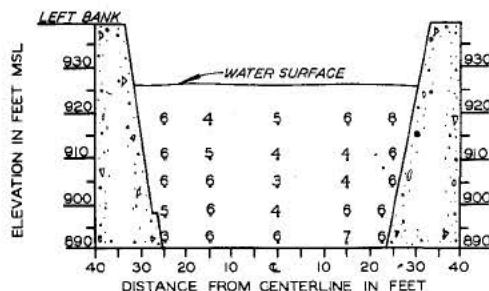
STATION 2+60



STATION 3+00



STATION 3+50

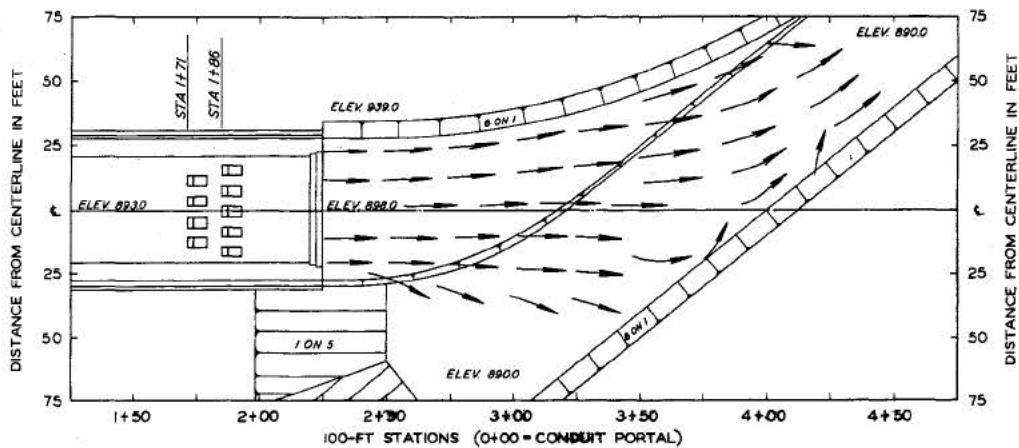


SECTION X-X

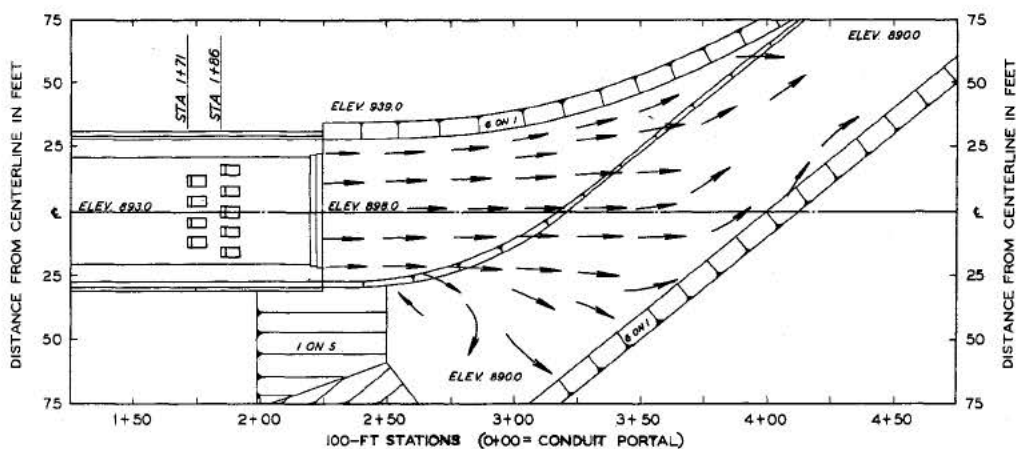
NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.
VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

VELOCITIES WITH ONE ROW OF BAFFLE PIERS

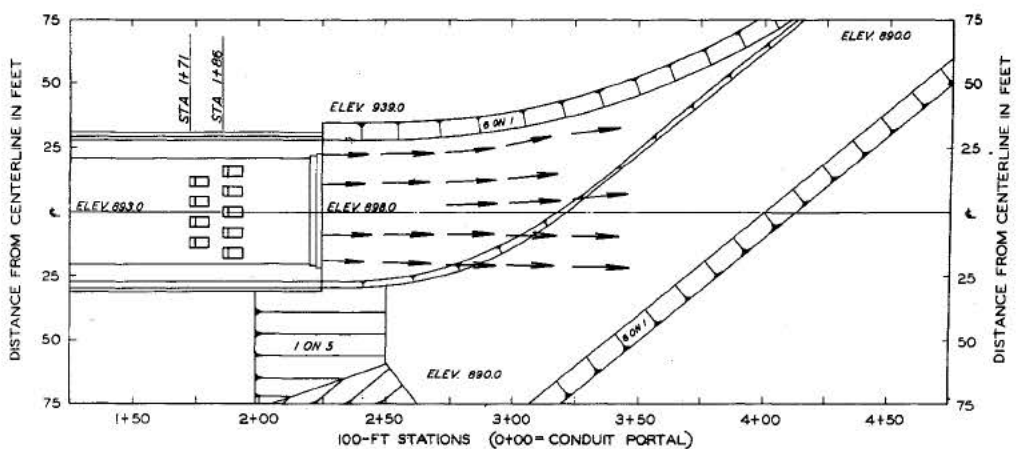
DISCHARGE 10,430 CFS
TAILWATER ELEVATION 926.5



DISCHARGE 11,750 CFS TAILWATER ELEVATION 934.0



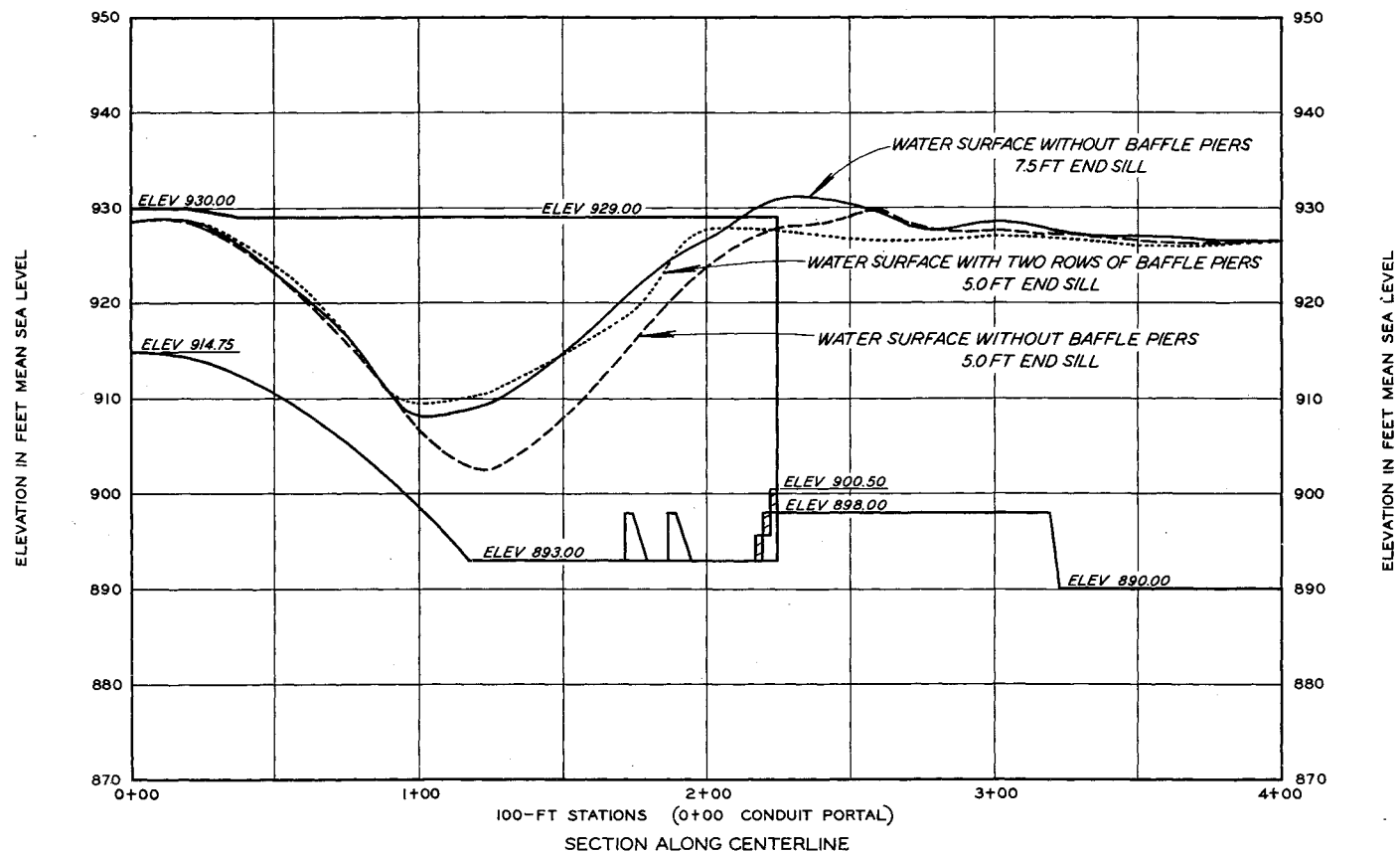
DISCHARGE 10,430 CFS TAILWATER ELEVATION 926.5



DISCHARGE 3,800 CFS TAILWATER ELEVATION 920.0

NOTE: ELEVATIONS ARE IN FEET MSL

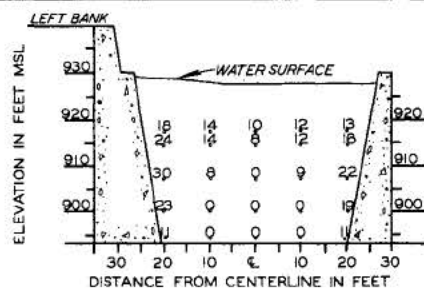
CURRENT DIRECTIONS
WITH TWO ROWS OF BAFFLE PIERS



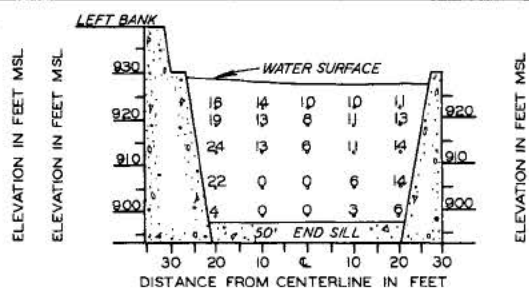
COMPARISON
WATER SURFACE PROFILES
DISCHARGE 10,800 CFS
TAILWATER ELEVATION 926.8 FT



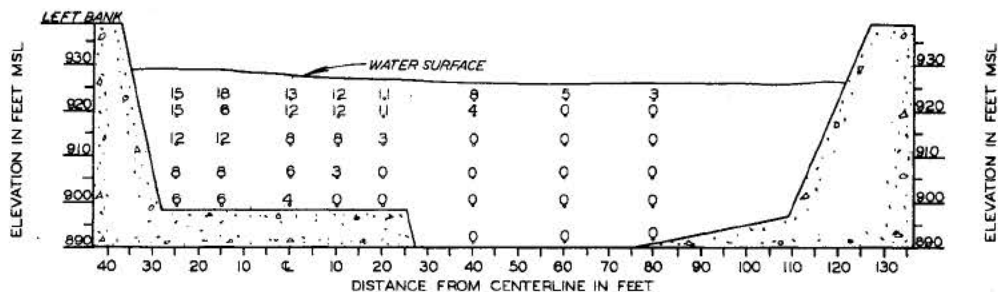
DISCHARGE 11,750 CFS
TAILWATER ELEVATION 934.0



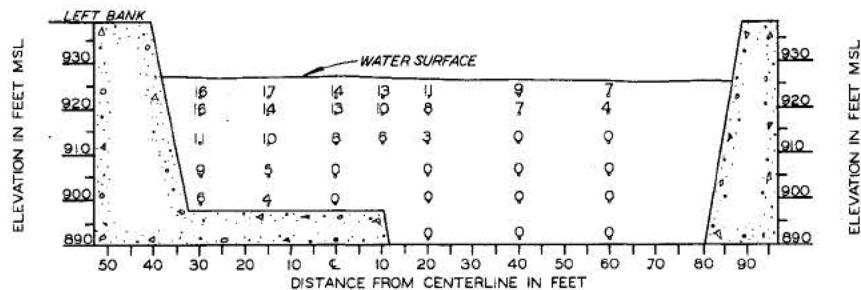
STATION 2+15



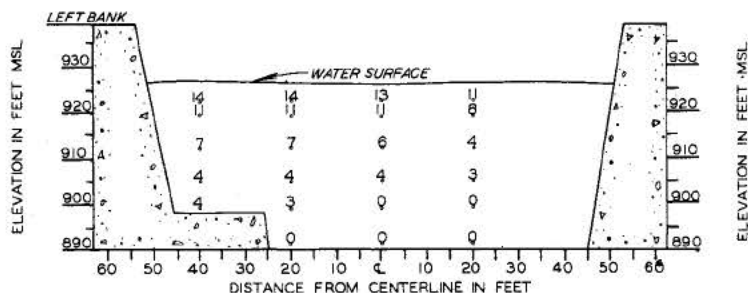
STATION 2+25



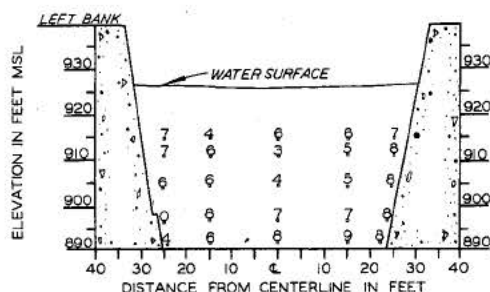
STATION 2+60



STATION 3+00



STATION 3+50



SECTION X-X

NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.

VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.

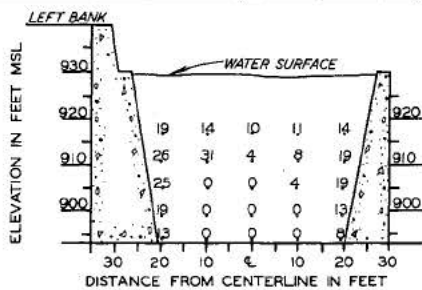
BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

VELOCITIES

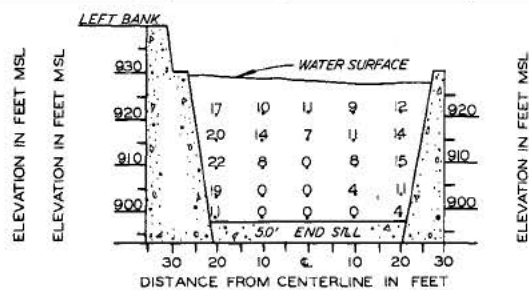
WITH TWO ROWS OF BAFFLE PIERS

DISCHARGE 10,800 CFS

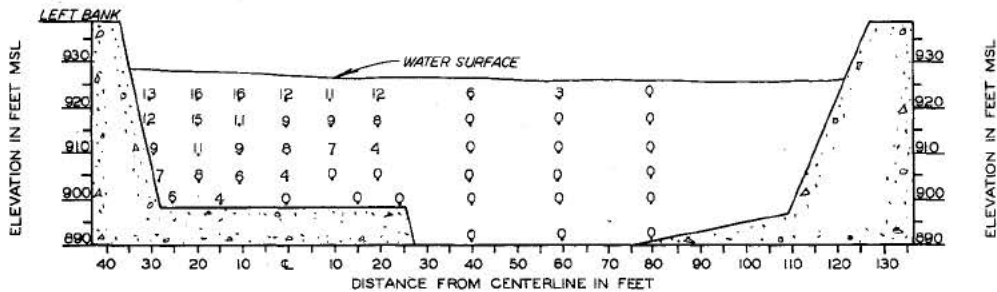
TAILWATER ELEVATION 926.8



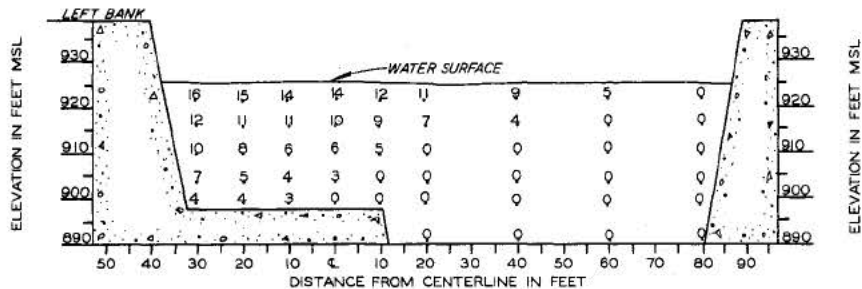
STATION 2+15



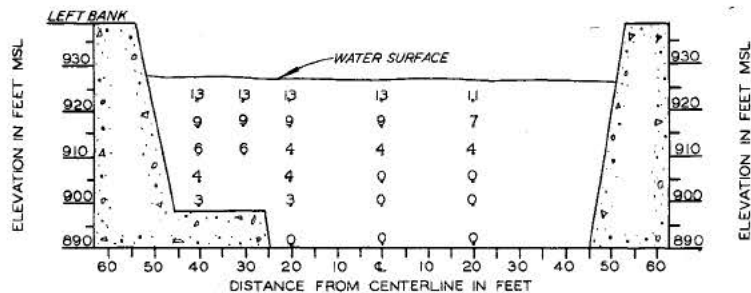
STATION 2+25



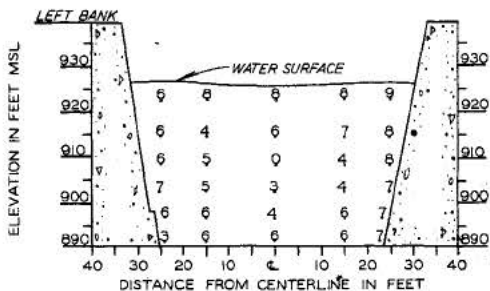
STATION 2+60



STATION 3+00



STATION 3+50



SECTION X-X

NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.

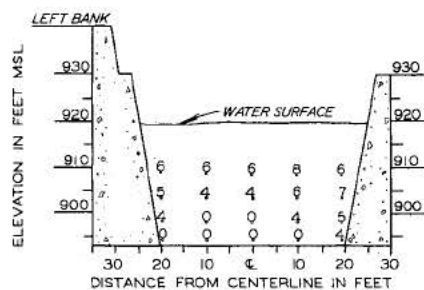
VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.

BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

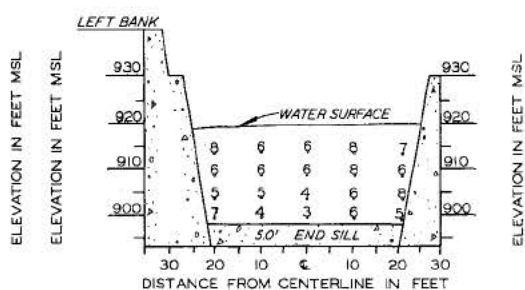
VELOCITIES

WITH TWO ROWS OF BAFFLE PIERS

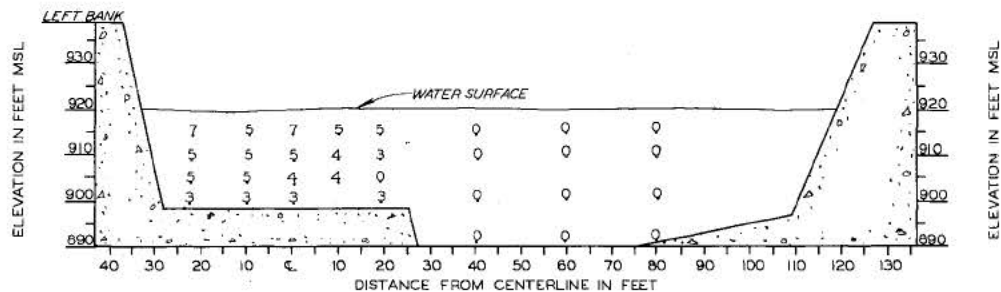
DISCHARGE 10.430 CFS
TAILWATER ELEVATION 926.5



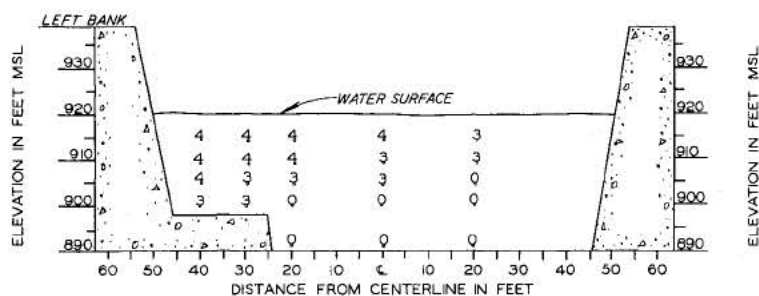
STATION 2+15



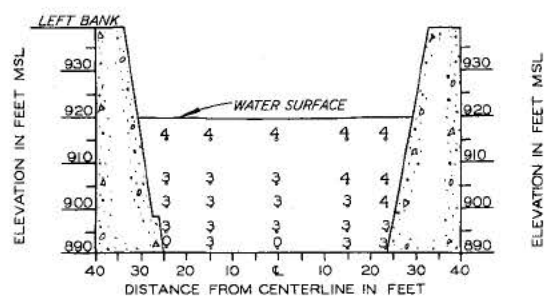
STATION 2+25



STATION 2+60



STATION 3+50

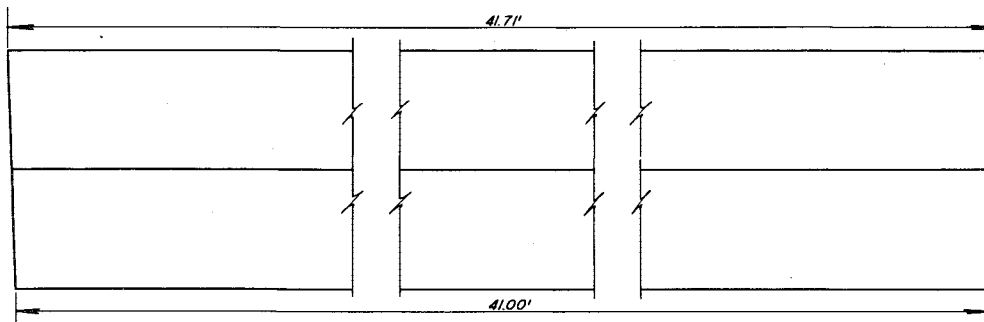


SECTION X-X

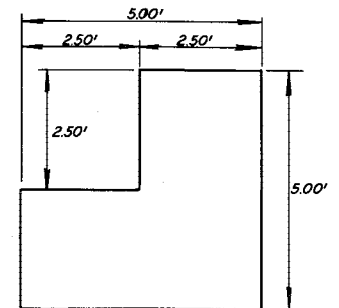
NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE
FEET PER SECOND
VELOCITIES ARE IN A DOWNSTREAM DIRECTION
EXCEPT WHEN PRECEDED BY A MINUS SIGN
WHICH INDICATES UPSTREAM FLOW
BED OF EXIT CHANNEL MOLDED IN CEMENT
MORTAR.

VELOCITIES WITH TWO ROWS OF BAFFLE PIERS

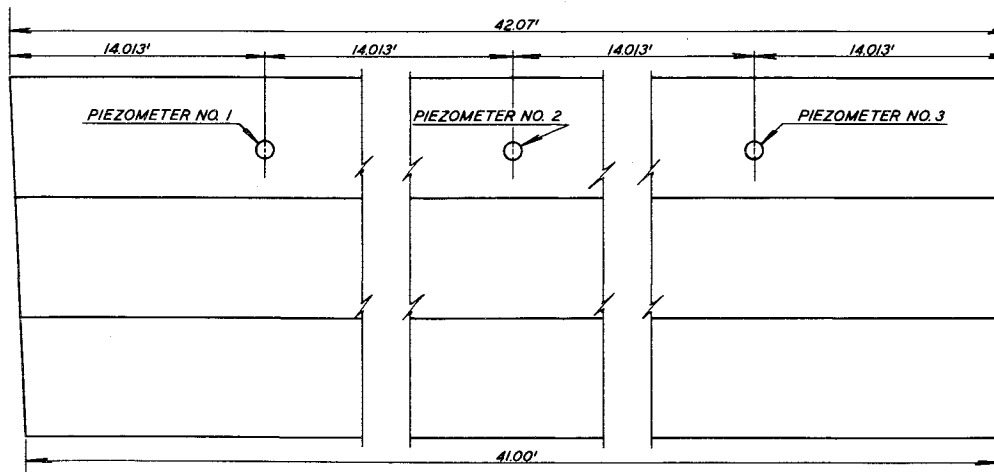
DISCHARGE 3,800 CFS
TAILWATER ELEVATION 920.0



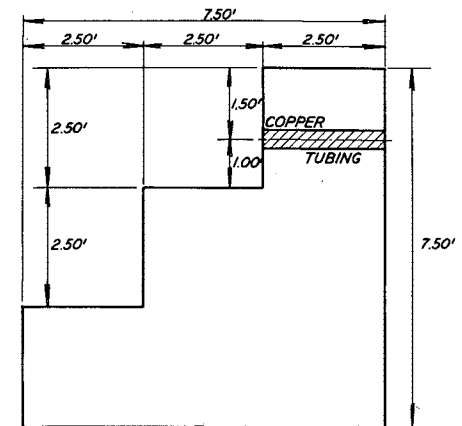
5.0FT END SILL- FACE ELEVATION



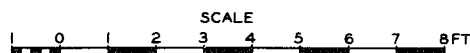
5.0FT END SILL-END ELEVATION



7.5FT END SILL- FACE ELEVATION

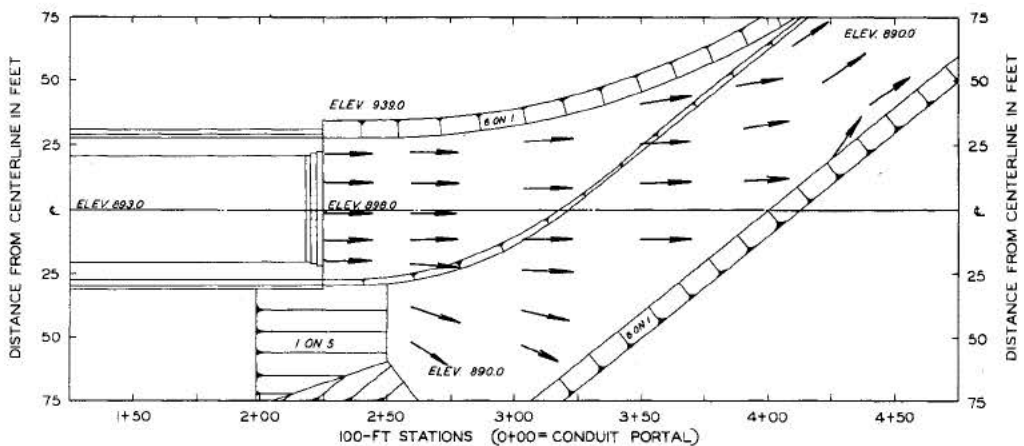
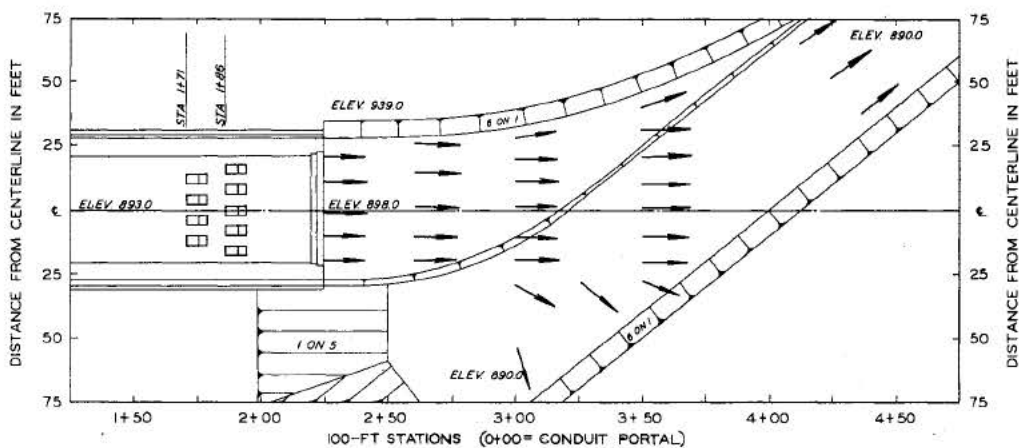
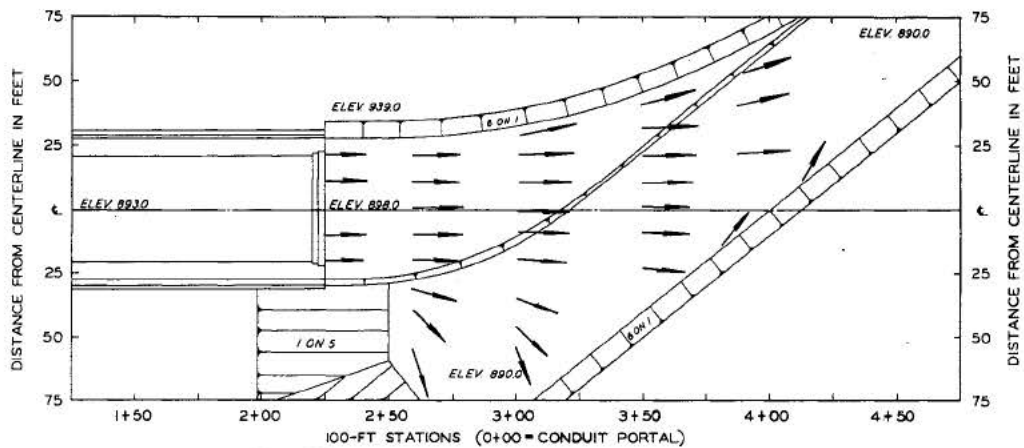


7.5FT END SILL-END ELEVATION



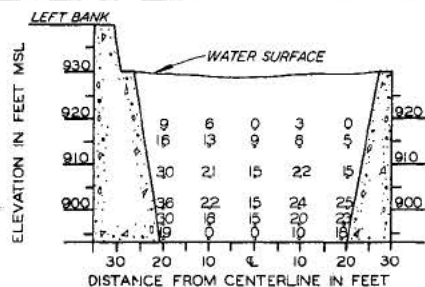
NOTE: ALL VALUES ARE IN PROTOTYPE UNITS.

DETAILS OF 5.0 & 7.5 FT END SILLS

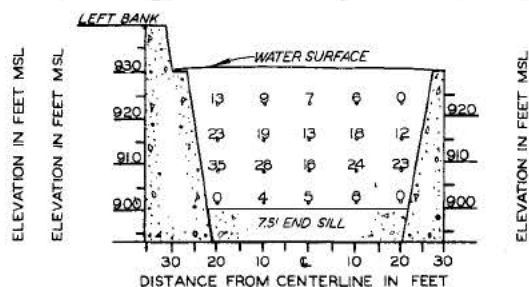


NOTE: ELEVATIONS ARE IN FEET MSL.

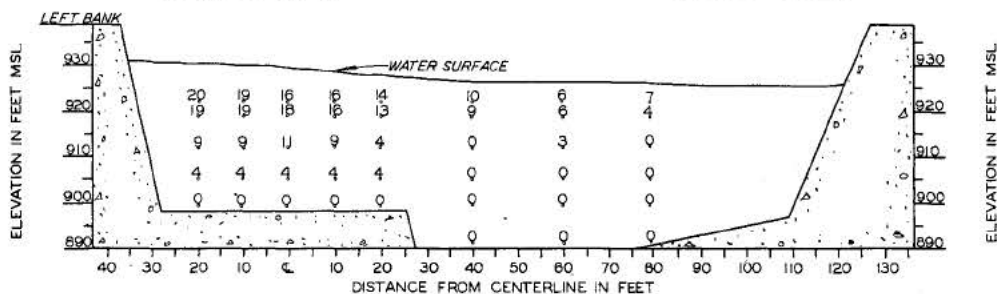
COMPARISON
CURRENT DIRECTIONS
DISCHARGE 10,800 CFS
TAILWATER ELEVATION 926.8



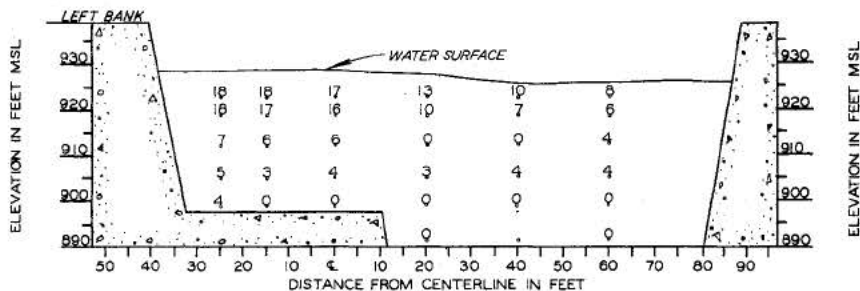
STATION 2+15



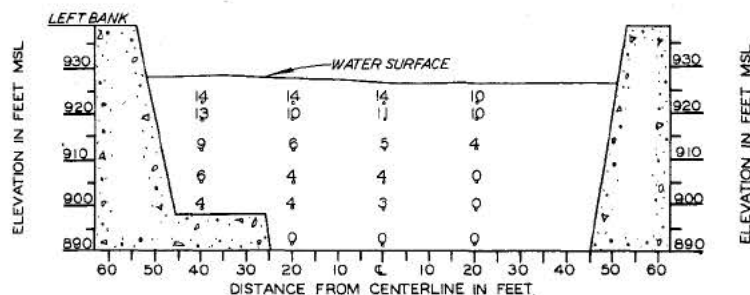
STATION 2+25



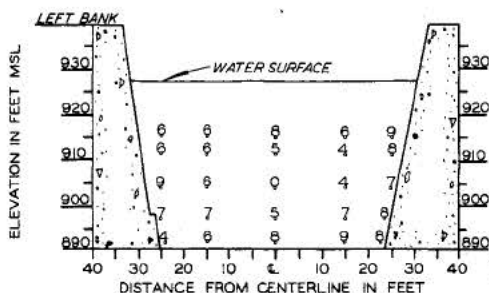
STATION 2+60



STATION 3+00



STATION 3+50



SECTION X-X

NOTE: VELOCITIES ARE RECORDED IN PROTOTYPE FEET PER SECOND.

VELOCITIES ARE IN A DOWNSTREAM DIRECTION EXCEPT WHEN PRECEDED BY A MINUS SIGN WHICH INDICATES UPSTREAM FLOW.

BED OF EXIT CHANNEL MOLDED IN CEMENT MORTAR.

VELOCITIES

7.5 FT END SILL WITHOUT BAFFLE PIERS

DISCHARGE 10,800 CFS

TAILWATER ELEVATION 926.8